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SUGARBEET RESEARCH

1993 REPORT

FOREWARD

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Trade names occur in this report solely to provide specific information and do not signify endorsement by the U.S. Department of Agriculture or the Beet Sugar Development Foundation.

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SUGARBEET RESEARCH

1993 Report

Section A

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BLUA, M.J., T.M. PERRING, G.S. NUESSLY, J.E. DUFFUS, and N.C. TOSCANO. Impact of cropping patterns on *Bemisia tabaci* and LIYV. Environmental Entomology (In press). 1994.

The sweetpotato whitefly, *Bemisia tabaci* (Gennadius), was trapped throughout the southern desert agricultural region of California during two consecutive growing seasons. Trap data revealed changes in whitefly population densities that provide insight into the epidemiology of lettuce infectious yellows virus (LIYV) in fall melon and lettuce. Whitefly abundance increased rapidly from July to September in cotton. During this period, there were significant correlations between the number of cotton fields in a region and the number of whiteflies trapped in that region. Beginning in August and September, whitefly densities increased in melon, and the proportion of viruliferous whiteflies increased in cotton and melon. After the defoliation of cotton was initiated in September, whiteflies migrated to melons, which not only served as their host but also as a reservoir for LIYV. In October and November high numbers of viruliferous whiteflies were found in melon and lettuce. As melons were harvested and the fields dried, viruliferous whiteflies migrated to newly emerged lettuce.

CAMPBELL, B.C., J.E. DUFFUS, and P. BAUMAN. Determining whitefly species. Science 261:1333-1334. 1993.

The statement in the report by T. M. Perring *et al.* that the "superbug" is not a strain of the sweetpotato whitefly, *Bemisia tabaci* (Gennadius), but a new species, seems premature. When more than 25 pairs of males and females of both strains were placed together, interstrain mating resulted in the production of viable, hybrid females. Field collections made in the Imperial Valley of California in 1992 revealed that feral populations of the two strains had interbred. Hybrid whiteflies that had fixed (not induced) esterase loci from both "A" and "B" strain parents were clearly identified.

Perring *et al.* used single primer polymerase chain reaction amplification (RAPD-PCR) and found that genetic differences between the strains were at a "species" level, but RAPD-PCR fragments have revealed only arbitrary differences between the DNAs. "Genetic distances" of a size similar to those between *B. tabaci* strains are likely to be observed if either strain is compared to RAPD-PCR fragments generated from any number of randomly selected taxa (for example, another whitefly strain or species, dogs, or nematodes). The RAPD-PCR results in the report by Perring *et al.* are of potential diagnostic value, but of little phylogenetic utility.

When one of us (B.C.C.) compared more than 2000 nucleotides of genes in the ribosomal RNA (rRNA) transcript from *B. tabaci*, which included three variable expansion regions, the rDNA in those strains was identical. Sequences of 28S rDNA D2 expansion regions (550 nucleotides) have been found to be identical in the *B. tabaci* strains, whereas 40 nucleotide substitutions have been found in ash and greenhouse whiteflies. The D2 expansion region has been used to deduce phylogenies of subgenera and sibling species of *Drosophila*. Whiteflies also have uncommonly elongated (≈2450 nucleotides) 18S rDNAs. This extra length stems from two internal, variable expansion regions (8). The 18S rDNA of the two *B. tabaci* strains has been found to be identical, whereas 60 to more than 100 nucleotide substitutions have been found in ash, iris, and greenhouse whiteflies. Sternorrhynchans (for example, aphids and whiteflies) have maternally heritable, procaryotic endosymbionts. An earlier study of endosymbiont 16S rDNA found that aphid endosymbiosis resulted from a singular infection of a primordial ancestor during the Triassic. Since that time, aphids and their endosymbionts have cospeciated, resulting in congruent phylogenies. Whitefly endosymbiosis follows a similar congruency, wherein endosymbiont 16S rDNA distinguishes whitefly species. Both strains of *B. tabaci* have two endosymbionts. The nucleotide sequences of 16S rDNAs (≈1600 nucleotides each) of the respective endosymbionts have been found to be identical in the *B. tabaci* strains, whereas 70 nucleotide substitutions have been found in greenhouse and ash whiteflies. In summary, our mating and phylogenetic studies do not support the conclusion of Perring *et al*. that the "superbug" is a new species of whitefly.

DUFFUS, J.E., H.Y. LIU, and S. COHEN. Partial characterization of a new closterovirus, the causal agent of cucurbit yellow stunting disorder. Pg. in Sweetpotato Whitefly: 1994 Supplement to the Five-year Plan, U.S. Dept. Agr. ARS No. 112. (In press). 1994

Whitefly-transmitted yellowing viruses of cucurbits are causing severe economic losses throughout the world. In western USA lettuce infectious yellows (LIYV), vectored by *Bemisia tabaci*, caused large losses to cucurbits, lettuce and sugarbeet. In the USA, Europe, Asia and the Mediterranean region beet pseudo yellow virus (BPYV), vectored by *Trialeurodes vaporariorum*, causes major losses in controlled environments and outdoors in warmer regions. In the early 1980's a yellowing and stunting disorder of cucurbits was noticed in the middle east. On the basis of observations and limited serological studies this disease appeared to be distinct from LIYV and BPYV.

This virus, herein named Cucurbit yellow stunting disorder virus (CYSDV), is transmitted by the sweetpotato whitefly (*Bemisia tabaci)* in a semipersistent manner. The virus appears to have

a narrow host range, mainly in the Cucurbitaceae. The virus can cause economically significant losses on melons and cucumbers. The virus has been purified by differential centrifugation. Purified preparations contained long, flexuous particles 12 x 1200 nm. The host range, insect transmission and serology clearly distinguish CYSDV from previously described viruses.

DUFFUS, J.E., H.Y. LIU, and G.C. WISLER. A new closterovirus of tomato in southern California transmitted by the greenhouse whitefly (*Trialeurodes vaporariorum*). Phytopathology (In press). 1994.

A previously undescribed virus disease of tomato was found in the Orange County area of southern California. Affected tomato plants exhibited interveinal yellowing, necrosis and severe yield losses. The disease affected virtually 100% of the crop in the Irvine hills and valley region. The outbreak was associated with the occurrence of high populations of the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood). Leaf dips showed flexuous filamentous particles of variable length similar to closteroviruses. The virus was transmitted by *T. vaporariorum* but not by either the A or B biotypes of *Bemesia tabaci* (sweetpotato whitefly). Further characterization by protein and RNA analysis and insect transmission studies will be necessary to determine the relationship of the new tomato virus to other whitefly-transmitted closteroviruses.

DUFFUS, J.E., H.Y. LIU, and G.C. WISLER. Lettuce chlorosis virus--A new whitefly-transmitted closterovirus in the southwest. Phytopathology (In press). 1994.

Lettuce infectious yellows virus (LIYV) has been a limiting factor in the production of crops in the desert regions of southwestern USA since 1981. Following the introduction of the B biotype of *Bemisia tabaci* into the region in 1990, the incidence of LIYV dropped significantly. A mixture of viruses including LIYV and a previously undescribed closterovirus herein termed lettuce chlorosis virus (LCV) have been isolated since 1991 from yellowed lettuce plants in the desert. LCV has long filamentous particles, and is transmitted by both the A and B biotypes of *Bemisia tabaci*. LCV can be distinguished from LIYV and other whitefly-transmitted closteroviruses by serology, dsRNA analysis, host range and insect-virus relationships.

DUFFUS, J.E. and E.G. RUPPEL. Diseases. Pg. 347-427 *in* The Sugar Beet Crop. D.A. Cooke and R.K. Scott, ed., Chapman and Hall. 1993. (Book Chapter)

Diseases have played an extremely important role in the current distribution of the beet sugar industry. The sugar-beet crop, a product of science, has largely depended for its success upon the ability of science to control destructive plant diseases.

The sugar-beet plants which were introduced from Europe to widely divergent areas of the world encountered numerous diseases unknown in their areas of development. Beet curly top virus virtually destroyed the sugar-beet industry in western USA in the 1920s and continued to be the principal factor limiting production in this region until the 1940s. In the absence of control measures (including resistant varieties and cultural methods) sugar beet could still only be grown in limited areas of western USA. Yellow wilt, first observed in Argentina in the 1920s, caused the complete collapse of the industry in that country and has severely limited the distribution of sugar-beet growing in Chile. Attempts to extend the cane sugar factory operations in the southern USA by using sugar-beet roots as an additional raw material failed completely because of the damage caused by two rots, *Rhizoctonia* crown rot and *Sclerotium* root rot. Rhizomania was first discovered in the mid-1950s on the Po river plains of Italy. By 1964 it had infested over 11,000 ha and caused their withdrawal from sugar-beet production. The disease was discovered in California in 1983 and has already been found in over 32,000 ha; it has caused some areas to go out of beet production and has seriously affected cropping in others.

This chapter reviews the literature of the major virus, fungal and bacterial diseases of sugarbeet.

DUFFUS, J.E. and D.C. STENGER. Squash leaf curl virus. C.M.I./A.A.B. Descriptions of Plant Viruses (In press). 1994.

Squash leaf curl virus (SLCV) is a virus with geminate particles, 22 X 38 nm. The circular single-stranded DNA genome is bipartite and consists of two similar-sized species. Known hosts are in the Cucurbitaceae, Leguminosae, Solanaceae, and Euphorbiaceae. The virus is transmitted by the whitefly, *Bemisia tabaci* and by inoculation with sap. The disease occurs in desert regions of the American Southwest and Mexico.

LEWELLEN, R.T. Case histories of early testing to identify sugarbeet lines with high performance. J. Sugar Beet Research 30:105. 1993.

Early testing is used to estimate the genetic potential of an individual or line at an early stage of development. The efficacy of early testing to identify improved lines of sugarbeet for general combining ability has been inconclusive. Monogerm line C762-17 was released in 1989 and lines C790-6, C790-15, and C790-54 were released in 1992. C762-17 was identified from pair-plant crosses between specific lines without recombination. Individual S_o plants within and among crosses were tested in 3-2ay hybrids. These tests identified plants that had better hybrid performance for sugar yield than their parental lines. Hybrids generated from S_o plants within paired crosses were more similar in performance than hybrids

among paired crosses. From population-790(C4) that had been improved by four cycles of S_1 progeny recurrent selection, 100 S_1 progenies were evaluated in three locations for components of yield and disease resistance. Based on these tests, eight S_1 progenies were selected and topcrossed. The S_1 lines that became C790-6, C790-15, and C790-54 had significantly higher hybrid performance than the corresponding population hybrid. The performance of these monogerm lines strongly support the usefulness of early testing in a sugarbeet hybrid breeding program.

LEWELLEN, R.T. Sources, breeding, and performance of resistance to rhizomania in sugarbeet. J. Sugar Beet Research 30:106. 1993.

Rhizomania resistance breeding has been in progress at Salinas since 1984. A wide array of germplasm has been screened. Other than the factors from Holly (*Rz*) and Rizor, high levels of resistance are rare within sugarbeet. In contrast, resistance to rhizomania has been identified from many *Beta maritima* accessions. Eight of these sources of resistance have been enhanced by backcrossing into sugarbeet. Segregation within F_1 and BC populations grown under rhizomania conditions usually suggest single dominant gene action. The allelic relationships of these different sources of resistance are not known. Tests of allelism between *Rz* and a factor from line PI 206407 (C28) suggested different genes. Field tests also suggested differences in performance. As the severity of disease increased, resistance from PI 206407 gave better protection than *Rz*. The combined resistance was better than either alone. In greenhouse and field tests, *Rz* and a factor from WB 42 (C48) reacted differently. In a field test under moderate and severe conditions, Rhizosen (*Rz* resistance) and Rizor had 30% reduction in yield, whereas a line with *B. maritima* sources of resistance (C50) had 6% additional loss. The effects of differences in gene frequencies and genetic backgrounds may have confounded these results and could not be discounted.

LEWELLEN, R.T. and E.D. WHITNEY. Registration of germplasm lines developed from composite crosses of sugarbeet x *Beta maritima*.

C48, C50, and C58 are sugarbeet germplasm lines developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation. These germplasm lines were derived from crosses between sugarbeet and *B. maritima* L.

C48 was released in 1988. It was developed from crosses of *B. maritima* lines WB41 and WB42 to C37 sugarbeet. Field tests showed that C48 is resistant to rhizomania. It has sugarbeet root and canopy type growth, is biennial, but in the absence of rhizomania has relatively low sugar concentration and yield.

C50 was released in 1988. It was developed from crosses of the Salinas collection of *B. maritima* accessions to Y54 sugarbeet. About 60 *B. maritima* accessions from Europe and the middle-East were successfully involved.

C50 is highly heterogeneous with 50% of the germplasm coming directly from *B. maritima*. It was released as a single population from which to search for desirable traits from *B. maritima* without the problems of growing many accessions with varying idiotypes and bolting tendencies. In an ongoing breeding program, it has been shown that C50 can be successfully used as a source of resistance to rhizomania and virus yellows.

C58 was released in 1989 as a source of disease resistance. It was developed from a composite of crosses made between C91 sugarbeet and *B. maritima* lines WB41, WB42, and WB151 from Denmark, WB187 and WB188 from England, WB318 from France, and WB169 from Italy. C58 is 50% *B. maritima*. It segregates for annualism, leaf and root color and shape, and disease resistance. In a series of greenhouse tests, 62% of the plants were highly resistant to rhizomania.

LIU, H.Y., J.E. DUFFUS and G.C. WISLER. Possible association of two soil-borne viruses with vascular necrosis of sugarbeet. Phytopathology 83:1421. 1993.

Two soil-borne viruses have been isolated recently from sugarbeet roots with vascular necrosis in the Imperial Valley of California. The infectious agents are mechanically transmissible. One of these viruses is isometric and approximately 25 nm in diameter. It contains a single species of single-stranded RNA of approximately 3.70 kb and a single capsid protein of approximately 31.0 kDa. Purified virus was infective and had an A_{260}/A_{280} ratio of 1.66. An antiserum to the purified virus had a titer of 1/512 in immunodiffusion tests. The particle morphology, protein coat subunits, and nucleic acid size are similar to those of tobacco necrosis virus (TNV). However, no serological relationship to TNV has been demonstrated in immunodiffusion and western blot analyses. Another spherical virus isolated form necrotic sugarbeet roots was serologically related to tomato bushy stunt virus. The distribution, economic importance, and the relationship of these viruses to the increasing vascular necrosis syndrome in the Imperial Valley is not known.

PILGERAM, A.L. and J.E. DUFFUS. Molecular analyses of *Polymyxa betae* and *Polymyxa graminis*. Phytopathology 83:1370. 1993

Polymyxa betae, the vector of beet necrotic yellow vein virus and beet soilborne virus, is an intracellular root parasite of plants within the Chenopodiaceae, Amaranthaceae, and Portulacaceae families. *Polymyxa graminis* is parasitic on

the roots of several grasses and vectors several devastating viruses (soilborne wheat mosaic virus, barley yellow mosaic virus, peanut clump virus, etc.). Although the host ranges of the two species are distinctive, morphologically they are quite similar. Ribosomal internal transcribed spacer sequences (ITS) from *Polymyxa*-infected root tissues have been amplified, and the products evaluated using restriction and RAPD analyses. ITS products from the two species, from *P. betae* isolates from different host plants, and from viruliferous and aviruliferous isolates of *P. betae* are compared.

WISLER, G.C., H.Y. LIU, and J.E. DUFFUS. Serological comparisons of beet necrotic yellow vein virus (BNYVV) with other rod shaped viruses of sugarbeet. Phytopathology 83:1421. 1993.

Five BNYVV isolates (three from California, one from Nebraska, and one from Idaho) and eight other rod-shaped viruses isolated from sugarbeet (two from Texas, five from Nebraska, and one from Idaho) were compared in western blot analyses. those antisera which reacted only to BNYVV were to; (1) the C-terminus of the BNYVV capsid protein (CP), (2) the 14-kDa and 75-kDa nonstructural proteins (courtesy K. Richards) and, (3) four monoclonal antibodies to the CP of BNYVV (courtesy G. Grassi and L. Torrance). An antiserum to the 25-kDa nonstructural protein (K. Richards) reacted with four of the BNYVV isolates, but not with one which had been maintained by mechanical transmission for several years. An antiserum to the whole virion of BNYVV reacted strongly with homologous BNYVV isolates (MW of c. 22-kDa), but weakly with the eight other rodshaped viruses of sugarbeet, with a MW of c. 24-kDa. In reciprocal tests, antisera to the two viruses from Texas reacted strongly with all eight rod-shaped isolates (c. 24-kDa), but weakly with the five BNYVV isolates (c. 22-kDa). An antiserum to the 42-kDa nonstructural protein (K. Richards) reacted with all BNYVV isolates (MW c. 42-kDa) and the eight other rod-shaped virus isolates (MW c. 43-kDa). All BNYVV isolates produced characteristic chlorotic local lesions on *Chenopodium quinoa*. Thus, BNYVV appears to be distinct form the other rod-shaped viruses of sugarbeet tested, based on the MW of the CP and reactivity with antisera to the 14-, 25-, and 75-kDa proteins.

YU, M.H. Biological Nematode Control in Sugarbeet Production. 7th Intnl. Congr. Soc. Adv. Breed. Res. Asia & Oceania. Abstr. p. 174. 1993.

Cyst nematode and root-knot nematode are important plant pathogens of sugarbeet and are difficult to control. Plant parasitic nematodes spend at least part of their lives in soil; therefore, their activities and populations are influenced by both physical and biological factors in the soil. Control of sugarbeet nematodes is thus predicated on the population

density, activation timing, biological limitation, chemical application, and host plants. Multi-year crop rotation has been used extensively to control the cyst nematode. Several trap crops, such as oil radish, yellow mustard, or resistant sugarbeet lines, can be used for intermediate cropping. Nematode parasitic bacteria, fungi and other microorganisms are being investigated. Genetic sources of resistance to cyst nematode and root-knot nematode have been identified from Patellares wild beets and sea beet. Breeding sugarbeet resistant to nematode would be the most economical and environmentally sound tactic for the control.

YU, M.H. Growth and Reproduction Performance of Ovule-Induced Sugarbeet Plants. Sabrao Journal. pp. 24(1):47-55. 1992.

Plants derived from ovule cultures of eight sugarbeet (Beta vulgaris L.) breeding lines were studied for growth, seed set, and progeny ploidy. Leaf characteristics of the majority of the ovule-derived plants differed from the donor plants in vigor, size, shape, and texture. Stomatal guard cells of 52% of the ovule-derived plants contained 6.6-9.9 compared to 12-16 chloroplasts for diploids. Monoploid and diploid sugarbeets shared a 10-11.9 chloroplast range. Sixty percent of the plants were found to have 2n root tip chromosomes. Over 73% of ovule-derived plants pollinated with diploids set seed. Seed quantity ranged from only a few to an almost normal amount: 48% had 50 seeds or less per plant. Most of the progeny plants were vigorous and normal in appearance, and had 18 chromosomes. The results indicated that the majority of ovule-derived plants were monoploids, yet their outcrossed progeny were diploids.

YU, M.H. Identification of root-knot nematode resistance for sugarbeet breeding. 17th Intl. Congress of Genet. Volume fo Abstr. p. 118. 1993.

Beta vulgaris L. is one of the top two sucrose producing plants and a favored host of nematodes. Meloidogyne spp. cause root gall symptoms which severely limit sugarbeet yields and quality. Control of nematode in sugarbeet fields is challenging due to the nematode's wide host range and the increasing stringent restrictions on nematicide application. Identification of resistance to root-knot nematode and incorporation of resistance to sugarbeet, thus, becomes important. Screening >300 Beta germplasms, a B. maritima L. accession that segregated plants free from root gall formation and M. incognita reproduction has been identified. This is the first root-knot nematode resistance for sugarbeet breeding.

Papers Published Since Abstracted in Previous Report

DUFFUS, J.E. Whiteflies and whitefly-borne viruses and increasing threat to world agriculture. Proc. Internat. Working Group Legume Viruses. p. 6. 1993.

DUFFUS, J.E., R.T. LEWELLEN, and H.Y. LIU. Implications of sweetpotato whitefly biotype changes on lettuce infectious yellows virus. J. Sugar Beet Res. 30:90. 1993.

LIU, H.Y. and J.E. DUFFUS. A new soil-borne virus from California. Sugar Beet Res. 30:106. 1993.

PILGERAM, A.L. and J.E. DUFFUS. Characterization of single cystosori isolates of Polymyxa betae. International Working Group on Plant Viruses with Fungal Vectors. Notreal, Canada. p. 23. 1993.

PILGERAM, A.L. and J.E. DUFFUS. Characterization of single cystosori isolates of Polymyxa betae. Sugar Beet Res. 30:111. 1993.

WISLER, G.C., J.E. DUFFUS, and H.Y. LIU. Partial characterization of some furoviruses infecting sugarbeet. Sugar Beet Res. 30:123. 1993.

WISLER, G.C., J.E. DUFFUS, and H.Y. LIU. Variations among Furoviruses associated with sugarbeet. International Working Group on Plant Viruses with Fungal Vectors. Montreal, Canada. p. 26. 1993.

YU, M.H. Root-knot nematode and susceptibility of Beta plants to infection. J. Sugar Beet Res. 30:124. 1993.

DEVELOPMENT OF SUGARBEET BREEDING LINES AND GERMPLASM

R. T. LEWELLEN

BREEDING LINES C76-43 and C76-89 - These multigerm, open-pollinated breeding lines were released in 1993. They should combine resistance to rhizomania (Rz) with good tolerance to virus yellows. Pair crosses were made between plants from C31-43 or C31-89 and R76, a near-isoline of C31/6 with resistance to rhizomania. Full sib seed that was known to segregate for Rz was progeny tested under bolting induction conditions and evaluated for yield and sucrose. Based upon nonbolting tendency, % sucrose, and yield, stecklings of eight pair crosses involving C31-43 and six pair crosses of C31-89 were selected, combined within lines and increased. C76-43 and C76-89 will be evaluated in 1994 tests. Similar material and their hybrids were evaluated in 1993 as R276, R276Y, R276-43, R276-89, and R282 (combined R276-43, R276-89). Results of the performance of these lines and hybrids are presented in this report.

BREEDING LINE C918 - The population C918 was released in 1993. C918 is a self-fertile, multigerm, genetic male-sterile facilitated, random mated population that segregates for resistance to rhizomania (Rz). It also should have moderate tolerance or resistance to virus yellows, curly top, powdery mildew, Erwinia, and bolting. C918 and similar populations (popns-909,-911,-913,-915) were developed so that selfed families could be used for progeny evaluations yet be easily recombined. C918 will have traits similar to C37 or C46, its principal germplasm base. The development of C918 is given in the release notice. It will have a high frequency of self-fertility (S^f) as it was developed from selected S_1 progeny lines that had been selfed at Salinas under paper bags in the greenhouse. (S^sS^s genotypes will not produce seed at Salinas). The performance of populations similar to C918 (2913,2915) and their hybrids is given in this report.

BREEDING LINES C909-34, C909-37, C911-4, C911-12, C911-14, and C911-50 - These lines were released in 1993. See release statement for greater details. As popn-918 (C918) was being developed, C37 and then C46 type lines were used as recurrent parents. As backcrossing and population improvement proceeded, populations-906,-907,-908,-909,-910,-911,-912,-913, and -915 were produced. Within population breeding and selection was done within these sources, including progeny (S_1, FS, HS) evaluations. C909-34 and C909-37 were extracted from popn-909 by S_1 progeny evaluation. C911-4, C911-12, C911-14, and C911-50 were extracted from population-911. These lines segregate for resistance to rhizomania (Rz) and generally to Erwinia root rot and other diseases important in California. Results of the evaluation of these lines has been given in previous reports as well as in this one.

BREEDING LINE C890 - C890 was released in 1993 as a population that segregated for resistance to rhizomania (Rz). Subsequently there was

evidence that this may not be so. C890 is a monogerm (segregates for monogerm), O-type, self-fertile ($\underline{S}^{f}$), genetic male-sterile facilitated, random-mated population that is similar to C790. It was developed by backcrossing a source of rhizomania resistance to C790mmaa. At the time of its release, it was thought that it could be used as a source for producing monogerm, O-type, rhizomania resistant progeny families for population and line improvement. Earlier versions of C890 have been tested as lines 1890, 2890, and 2891. Progeny families from 2891 were evaluated and results are presented in this report.

BOLTING EVALUATION - The winter/spring/summer of 1992-93 at Salinas appeared to provide good bolting induction conditions. These results need to be viewed with caution, however. Bolting is under the influence of many factors, e.g., vigor of plant, nitrogen status, shading and other micro-climatic effects from intra- and inter-plot competition, plant populations, disease incidence and severity. That is, anything that influences growth rate appears also to influence bolting tendency. One factor that is very difficult to control is environment of the seed development. It is well known that seed developed under cool conditions (e.g., Spence field at Salinas) will express higher bolting than seed produced under warm conditions (e.g., the greenhouse isolation chambers at Salinas). Line vs. the apparent bolting tendency in hybrids can also be misleading, in part due to vigor and growth rate of the hybrid compared to a weaker line. Thus, although these appear to be good bolting tests, caution is needed and data and experience over years, locations, seed lots, etc. are needed to make definitive judgements about bolting tendency. Nonetheless, the rates of bolting in these tests suggest that selection for non-bolting tendency should be effective. A number of both multigerm and monogerm lines and populations were selected for nonbolting tendency in 1993-94.

SOURCES OF RESISTANCE TO RHIZOMANIA - Eleven sources of resistance to rhizomania have been backcrossed into C37 germplasm. All of these are targetted for release in 1994. In most cases it is yet undetermined what the allelic relationship is among these sources. Some are likely to have the same factor(s) for resistance. Sources of resistance include Rz (Holly), PI206407 (chard, C28), R22 (B.maritima, C50), WB42 (C48), WB41 (B.m. from Denmark), R04 (weed beet from Italy), R05 (obsolete Italian sugarbeet), Rima, WB151 (B.m. from Denmark), WB169 (B.m. from Italy collected by Coons), WB258 (B.m. from Italy collected by DeBiaggi in 1979). Results of some of this program are presented in this report. The breeding line numbers used to identify some of this material include R222R4 (R22), R232 (R04), R228 (PI07), R279 (Rz), 90-WIV (WB151), and R207/R208 (R05).

PERFORMANCE OF R22 SYNTHETICS - R22 population (released in unselected version as C50) is about 50% sugarbeet (line C54) and 50% a composite of Beta martima germplasm. From the unselected F_3 synthetic R722, selections have been made for both resistance to virus yellows (see Tests 693, 893, 1393) and resistance to rhizomania (see Tests 693, B293, R793, R593, 2793, 2893, 2393, 2493). These selections were made to help assess

the genetic variability within B.maritima for disease resistance and factors for productivity. Results from the virus yellows selection program suggest that partial resistance to yellows occurs within B.maritima. Even more striking, there is evidence for high resistance to rhizomania. Because these resistance selections were partially based upon root and sugar yield (for virus yellows resistance), there is also evidence that factors for increased productivity may occur in B.maritima. The performance of R22 synthetics is given throughout this report and in the following tables.

SUGAR YIELD (lbs/a) UNDER SEVERE RHIZOMANIA,
BRAWLEY, CA

Variety		Date of Harvest 4/15	5/12	7/01	5/18*	% Rot 7/01
US H11	Susc.Hybrid	2500	1500	0	7800	96
HH 41	Susc.Hybrid	2300	2300	20	8900	92
Rima	Resist.Hybrid	4000	3000	2300	8800	43
Rhizoguard	Resist.Hybrid	3200	2500	1800	8500	55
R22R4	Cycle 4 Sel.	8400	8200	7000		20

Test B293; Pltd 9/24/92, Harvd 1993.
*Test B793; Pltd 9/24/92. Non-rhizomania check.

SUGAR YIELD (lbs/a), SALINAS

Variety		Rhizomania None[1]	Severe[2]	Severe[3]
US H11	Susc.Hybrid	11400	3700	1500
Rizor	Resist.Hybrid	13000	6500	4000
Rhizosen	Resist.Hybrid	12100	5400	3300
R22R4	Cycle 4 Sel.	10900	8400	5600
LSD (.05)		1100	1000	500

[1]Test 2293: Pltd 4/20/93; Harvd 10/26/93.
[2]Tests 2493 & 2793: Pltd 5/13/93; Harvd 11/4/93
[3]Test R593: Pltd 6/10/93; Harvd 11/22/93.

US H11	Susc.Hybrid	--	3400	1700
Rhizoguard	Resist.Hybrid	17800	6100	3100
mmCMS x R22R4		16700	7700	4700
LSD (.05)		900	1100	600

[1]Test 1093: Pltd 2/2/93; Harvd 9/22/93.
[2]Test 2393: Pltd 5/13/93; Harvd 11/2/93.
[3]Test R793: Pltd 6/10/93; Harvd 11/18/93.

RESISTANCE TO CYST NEMATODE - Cyst nematode resistant line C603 was derived from a cross with B883 from the Netherlands. In field tests at Salinas, it appeared to be resistant to the prevalent populations of Heterodera schachtii. In 1992, seed of C603, B883, B.procumbens, US H11, and others was furnished Dr. Lawrence Miller at VPI and State University. The purpose of these tests was to determine if isolates of H. schachtii from other locations could reproduce on C603. The results of these tests are presented below in the table.

REPRODUCTION OF ISOLATES OF BCN

	Isolates of H. schachtii					
Variety	C1	C2	N1	M1	F1	F2
US H11	+	+	+	+	+	+
B.procumbens	-	-	-	-	-	-
B883	-	-	-	-	-	-
C603	-	-	-	-	-	-

Data from L.Miller, VPI, 1994. Variation in development of five isolates of Heterodera schachtii on six sugarbeet x Beta procumbens interspecific hybrids. J.Nematology 26 (In press); and L. Miller. 1994. Development of four isolates and two intraspecific hybrids of Heterodera schachtii on three sugarbeet x Beta procumbens interspecific hybrids. Phytopathology 84 (In press).

C1 from tomato (CA); C2 from sugarbeet (CA); N1 from cabbage (NY); M1 from sugarbeet (MI); F1 & F2 from cabbage (Florida)

Subsequent to these studies, Dr. Miller identified an isolate called LSOG that in preliminary tests reproduced well on B.procumbens.

PERFORMANCE OF CYST NEMATODE RESISTANT HYBRIDS - Nematode resistant lines, populations, and hybrids were included throughout the testing program in 1993 (see results in this report). These materials are usually identified with an "N" prefix. Emphasis in the nematode resistance program is to combine resistance with rhizomania and other needs in germplasm with adaptation to the Western USA. The one constant with nematode resistant material is the very low sugar concentration. There is preliminary evidence however that under dual rhizomania/cyst nematode infested conditions, a hybrid with dual resistance is protected against both. Hybrid N203H15 which combines nematode resistance from C603 with rhizomania resistance from popn-915 under performed other hybrids in the absence of both diseases but out performed rhizomania resistant hybrids when tested under both conditions. These preliminary results are presented in the following table.

PERFORMANCE OF NEMATODE RESISTANT HYBRIDS

Test Hybrid	Sugar lbs/a	Root Yield t/a	Sucrose %
1093, Salinas, without RZM & BCN			
4757	18400	64	14.5
mm x C603	14700	62	11.8
1293, Salinas, without RZM & BCN			
Rhizoguard	15900	55	14.4
mm x C603	14500	59	12.4
Rz x C603	15800	64	12.3
1693, Salinas, BYV/BWYV infected without RZM & BCN			
mm x R82	11500	37	15.4
mm x C603	7400	31	11.8
2493 & 2793, Salinas, Rzm & BCN			
US H11	3700	14	13.0
Rhizosen	5500	18	15.3
Rz x C603	6400	24	13.3
3293, Salinas, Rzm & BCN			
US H11	4900	21	12.0
Rhizosen	7100	24	15.1
mm x C603	5200	24	10.8
Rz x C603	8200	32	12.9
B493, Brawley, without RZM & BCN			
HH 41	8700	31	14.4
mm x C603	6100	26	11.7
B693, Brawley, without RZM & BCN			
HH 41	9700	34	14.3
Rz x C603	7000	32	11.0

Starting with B883 as the source of nematode resistance, BC_4 lines will be produced in 1994. These backcross populations theoretically will be about 97% curly top resistant germplasm and will have rhizomania resistance. From these, a selfing program will be initiated to fix resistance to cyst nematode, rhizomania, and other desired traits. Hopefully within these, lines can be identified that will approach commercial usefulness.

RESISTANCE TO ERWINIA and POWDERY MILDEW - The tests to evaluate reactions to Erwinia root rot (ERR) appeared to be good in 1993. A mixture of isolates was used to inoculate the tests. However, tests by Dr. A. Pilgeram suggested that the 1991 isolate from Imperial Valley was the most prevalent one to cause soft rot in the field. With the high emphasis on

rhizomania resistance and the conversion of breeding lines to resistance to rhizomania, there appears to have been a general erosion in resistance to Erwinia, powdery mildew, and bolting, as well as curly top, virus yellows, sucrose percentage, etc. within the base lines. Renewed efforts and emphasis are being made in 1994 to upgrade the combined resistance and performance of the Salinas germplasm base. The following Table summarizes briefly and demonstrates the loss of combined resistance in the rhizomania resistant germplasm.

COMPARISON OF DISEASE REACTIONS
BETWEEN NEAR-ISOLINES

Near-Isoline	Erwinia DI[1]	PM Score[1]	Bolting %[2]
C37	3	4	11
R79 (C37Rz)	10	5	21
C46/2	6	2	7
R78 (C46/2Rz)	23	3	27
C54	5	3	7
R80 (C54Rz)	24	4	21
C31/6	11	1	15
R76 (C31/6Rz)	23	3	35
C39	10	1	18
C39R	31	1	39

[1]Test 2193: Planted 4/20/93, Inoc Ecb 7/15/93.
[2]Test 493: Planted 11/12/92. Counted 7/8/93.

VIRUS YELLOWS RESISTANCE - Breeding for resistance to virus yellows (BYV/BWYV) has been an ongoing program at Salinas since 1955. Even though progress has been very slow, particularly for resistance to BYV, it is evident that compared to nonselected materials, tolerance to virus yellows has been achieved in this program. This is evident in the virus yellows tests and is demonstrated in the Table below. The breeding lines developed in the virus yellows program have been used as the base for the rhizomania resistance program. As shown above, there has been a general loss of combined disease resistance during this program. However, it appears that it has been possible to combine rhizomania resistance with the existing levels of virus yellows tolerance.

BYV/BWYV INOC. & NON-INOC. TESTS, SALINAS

Variety[3]	Non-inoc[1] SY lbs/a	Non-inoc[1] Sucrose %	BYV/BWYV[2] SY lbs/a	BYV/BWYV[2] Sucrose %	Relative SY[4] %
KW 6770	19700	17.2	8300	16.8	42
US 75	15100	13.4	6100	13.2	40
C31-43,-89	19900	15.7	12900	15.9	65
R82	19500	14.8	12500	15.4	64

[1]Test 893: Pltd 2/6/93.
[2]Test 1493: Pltd 3/9/93; BYV/BWYV inoc 5/6/93.
[3]KW 6770 = high % sugar hybrid for Red River Valley. US75 = obsolete,CTR,NB,OP variety. C31-43, -89 = lines tolerant to virus yellows. R82 = rhizomania resistant near-isoline of C31-43,-89.
[4]Relative loss calculated from adjacent tests that were planted and harvested at different times.

TEST 693. EVALUATION OF Y54 x B.m. GERMPLASM LINES, SALINAS, CA., 1993

12 entries x 8 replications, RCB
1-row plots, 20 ft. long

Planted: February 16, 1993
Harvested: September 29, 1993

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100′ No.	Powdery Mildew Mean	RJAP %
Set 1 (693-1) Hybrids									
R280H20	87-309H3 x R080	19817	60.76	16.3	0.4	0.5	134	7.4	85.0
Y954H20	87-309H3 x Y854	19459	59.09	16.5	0.0	0.0	141	6.7	84.8
R222R4H20	87-309H3 x RZM R122R3	18942	60.49	15.7	2.2	0.0	144	8.0	82.9
Rhizoguard	L893301	18682	57.95	16.1	0.0	1.0	126	7.2	86.1
Set 2 (693-2) Lines									
R280Y (Iso)	RZM-BYV-ER R080	19374	61.38	15.8	0.0	0.0	135	5.3	84.6
Y954	Inc. Y854	19354	58.86	16.4	0.0	0.0	123	4.6	85.6
R022Y	Inc. R922Y	19246	60.23	16.0	0.0	0.0	132	5.4	84.0
R122Y2	BYV R922Y	18878	59.55	15.9	0.4	0.0	132	5.0	83.5
R122R3	RZM R022R2	18135	59.87	15.2	4.3	0.4	135	7.7	82.6
R222R4	RZM R122R3	17533	59.11	14.9	9.8	0.5	130	6.9	81.9
R221	RZM R121 (C48)	16941	52.83	16.0	0.0	0.0	128	6.8	83.5
R722	Inc. F_2(Y54 x B.m.)(C50)	15531	51.20	15.2	25.3	0.0	129	5.6	83.1
Mean		18490.9	58.44	15.8	3.5	0.2	132.3	6.4	84.0
LSD (.05)		1442.2	4.59	0.5	3.3	0.9	11.6	0.8	1.2
C.V. (%)		7.7	7.89	3.0	93.2	427.4	8.8	13.0	1.4
F value		6.2**	3.76**	9.7**	40.7**	1.2NS	2.2*	15.3**	9.4**

Notes: Test was grown in an area without rhizomania. BWYV infection was evident by June, but BYV infection remained low. Powdery mildew developed late, after the effects of Bayleton ceased. PM was scored 9/14 & 9/27/93. Erwinia spread from nearby inoculated trials and accounted for the root rot.

[1]Y854 = C54. R080 is near-isogenic Rz_ line of C54. R722 = F_3 (sugarbeet x B.maritima) source population. R3 and R4 are third and fourth cycle synthetics selected for resistance to rhizomania among 4 month old roots where selection was based upon root type and freedom from rhizomania symptoms. Y and Y2 are first and second cycle synthetics selected for resistance to virus yellows (BYV/BWYV) where 7 month old infected plants were selected on the basis of root size, shape, and % sucrose. R221 is C37 type with rhizomania resistance from WB41 and WB42.

TEST 793. YIELD EVALUATION OF SELF-FERTILE LINES AND POPULATIONS, SALINAS, CA., 1993[1]

48 entries x 6 replications, RCB
1-row plots, 20 ft. long

Planted: February 16, 1993
Harvested: October 6-7, 1993

Variety[1]	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	RJAP %	Powdery Mildew Mean[5]
Set 1 (793-1)									
Rhizoguard	L893301	17432	58.94	15.6	0.0	---	123	85.1	7.8
U86-37	Inc. C37, L86443	16169	51.14	15.8	0.0	---	125	84.1	7.7
Z220	RZM Z120,Z122,Z124	19509	59.49	16.4	0.0	---	138	83.7	6.3
Z230	RZM Z120-Z124aa x 1913,1915	19122	58.66	16.3	0.0	---	130	85.1	6.3
5747	4747aa x A	18153	58.32	15.6	0.0	---	127	84.3	7.6
0910	RZM 9910H47 (A,aa)	18754	62.09	15.1	0.0	---	136	82.8	7.2
2910	Inc. 1210(C)	17942	58.17	15.4	0.0	---	139	83.7	7.4
R129	RZM 0281-#	17300	60.48	14.3	1.3	---	138	82.0	6.5
R229	Inc. 1206(C)	19169	64.68	14.8	1.2	---	143	83.7	7.3
R233	Inc. 1205(C), (x R04)	17819	62.58	14.3	20.6	---	130	82.9	7.3
0909-34	Inc. 8909A-34, (C909-34)	17836	55.34	16.1	0.0	---	128	83.9	3.2
0909-37	Inc. 8909A-37, (C909-37)	17991	56.58	15.9	0.0	---	129	84.9	2.9
Mean		18099.7	58.62	15.5	1.9	---	132.2	83.9	6.5
LSD (.05)		1863.3	5.64	0.6	3.4	---	11.5	1.7	0.7
C.V. (%)		8.9	8.31	3.6	153.9	---	7.5	1.8	9.6
F value		2.0*	3.38**	10.1**	24.0**	---	2.4*	2.5*	43.5**

[1]TEST 793. YIELD EVALUATION OF SELF-FERTILE LINES AND POPULATIONS
48 entries x 6 replications, Incomplete blocks with 4 subsets, each 12 varieties x 6 replications, RCB.
Thus means across Tests 793-1,-2,-3,-4 can be compared.

Mean	18535.2	59.35	15.6	0.5	0.2	131.8	83.6	5.3
LSD (.05)	1725.1	5.27	0.6	1.7	0.9	11.7	2.0	0.8
C.V. (%)	8.2	7.80	3.5	292.6	464.9	7.8	2.1	13.1
F value	2.3**	2.62**	4.3**	22.7**	1.8**	4.4**	1.1NS	20.5**

Note: Test was grown in a field plot area free of rhizomania and cyst nematode. Virus yellows was mild and mostly BWYV. Powdery mildew was controlled until late summer with Bayleton. Aphids were controlled with Metasystox-R and Lorsban. Root rot was counted at harvest and due to spread of Erwinia.

TEST 793. YIELD EVALUATION OF SELF-FERTILE LINES AND POPULATIONS, SALINAS, CA., 1993[1]

(cont.)

Variety[2]	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100′ No.	RJAP %	Powdery Mildew Mean
Set 2 (793-2)									
0911	9911aa x A	18165	57.75	15.8	---	---	133	83.8	6.1
2911Y	RZM-BYV-ER 0911 (A,aa)	18260	58.94	15.5	---	---	138	83.1	5.8
2911- 4	RZM 1911- 4, (C911- 4)	19011	60.06	15.8	---	---	143	82.4	4.0
2911-12	RZM 1911-12, (C911-12)	19537	62.44	15.7	---	---	135	83.1	5.7
2911-14	RZM 1911-14, (C911-14)	17046	53.27	16.0	---	---	138	82.4	5.0
2911-50	RZM 1911-50, (C911-50)	19159	62.72	15.3	---	---	128	84.0	4.9
2913	RZM 1913 (A,aa)	19038	59.96	15.9	---	---	134	83.1	5.5
2913Y	RZM-BYV-ER 0913	18295	58.59	15.6	---	---	141	82.4	4.7
2913- 5	RZM 1913- 5	18530	60.69	15.3	---	---	138	83.2	4.8
2913-18	RZM 1913-18	18352	58.85	15.6	---	---	134	83.3	4.3
2913-22	RZM 1913-22	17823	57.68	15.4	---	---	135	82.6	4.3
2913-25	RZM 1913-25	18414	57.96	15.9	---	---	142	84.1	3.3
Mean		18469.1	59.08	15.7	---	---	136.5	83.1	4.8
LSD (.05)		1725.1	8.10	0.6	---	---	12.5	1.8	0.6
C.V. (%)		8.1	5.54	3.4	---	---	7.9	1.9	10.7
F value		1.2NS	1.62NS	1.3NS	---	---	1.0NS	0.9NS	15.1**

[1]Evaluation of lines and progeny families per se. Z220 & Z230 combine Rz with germplasm from high %S Polish accessions. 4747 = MM,S^f,A:aa popn similar to C37. 0910 & 2910 = Rz isoline of 5747. R129 & R229 = 5747 with PI206407 resistance to rhizomania. R233 = 5747 with R04 resistance to rhizomania. C909-34 & -37 rhizomania resistant progeny selections.

[2]0911, 2911Y, 2913, 2913Y = MM,S^f,A:aa popns with Rz 5747 & 903 (similar to C46) backgrounds. 2911-# & 2913-# = reselected progeny lines from popn-911 and -913.

TEST 793. YIELD EVALUATION OF SELF-FERTILE LINES AND POPULATIONS, SALINAS, CA., 1993[1]

(cont.)

Variety[3]	Description[3]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	RJAP %	Powdery Mildew Mean
Set 3 (793-3)									
2915	RZM 1915-# (C)	18202	59.99	15.2	0.6	0.6	137	83.6	3.5
2915Y	RZM-BYV-ER 0915 (A,aa)	18730	60.48	15.5	0.0	0.0	139	84.3	4.8
2915	RZM 1915, 1913aa x A	18950	60.76	15.6	0.8	0.0	123	83.9	4.6
0911- 1	9911aa x 9911,9911H49	19714	63.07	15.6	0.0	0.6	135	83.7	3.3
0911-4B	9911aa x 9911,9911H49	18688	57.23	16.4	0.0	0.0	125	84.4	5.0
2911-24	Inc. 0911-24 (A,aa)	20653	66.43	15.5	0.0	2.4	139	83.5	5.4
0913-6	9911H49aaa x 9911,9911H49	18210	55.86	16.3	0.0	0.0	139	83.1	5.2
2913-9	Inc. 0913-9 (A,aa)	18295	58.03	15.8	0.0	0.0	141	83.8	4.9
0915-1	9903aa x 9911,9911H49	18940	58.75	16.1	0.0	0.0	114	84.2	4.8
2915-4	Inc. 0915-4 (A,aa)	19004	60.65	15.7	0.0	0.0	143	83.6	5.9
0915-6	9903aa x 9911,9911H49	19161	60.62	15.8	0.0	0.0	133	84.1	5.1
2915-7	Inc. 0915-7 (A,aa)	19576	61.60	15.9	0.0	0.0	142	84.0	4.4
Mean		19010.3	60.29	15.8	0.1	0.3	134.2	83.8	4.7
LSD (.05)		1547.6	4.84	0.5	0.8	1.2	12.1	1.9	0.8
C.V. (%)		7.0	6.93	2.7	608.7	349.7	7.8	1.9	13.7
F value		1.7NS	2.63**	4.0**	0.9NS	2.6*	4.3**	0.3NS	7.6**

[3]2915, 2915Y, 2915 = MM,S^f,A:aa popns with Rz and popn-903 background.

TEST 793. YIELD EVALUATION OF SELF-FERTILE LINES AND POPULATIONS, SALINAS, CA., 1993[1]

(cont.)

Variety[4]	Description[4]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	RJAP %	Powdery Mildew Mean
Set 4 (793-4)									
0915-22	9903aa x 9911,9911H49	19003	58.94	16.1	---	0.7	124	83.3	4.7
0915-23	9903aa x 9911,9911H49	19570	63.80	15.3	---	0.0	120	82.4	4.1
0915-24	9903aa x 9911,9911H49	20122	63.63	15.8	---	0.0	136	83.6	4.9
0915-27	9903aa x 9911,9911H49	19564	61.93	15.8	---	0.0	112	84.2	4.5
0915-34	9903aa x 9911,9911H49	18324	58.60	15.6	---	0.0	101	84.0	4.9
2915-46	Inc. 0915-46 (A,aa)	17286	55.76	15.5	---	0.0	136	83.8	4.3
0915(C)	9903aa x 9911,9911H49	20549	64.26	16.0	---	0.0	128	83.8	4.6
2916	1905aa x 1913,1915	18994	60.27	15.8	---	0.0	128	84.9	5.3
0790	8790-S_1(C5)aa x A, (C790)	17839	56.07	15.9	---	0.0	134	82.9	4.5
2890(C)	0790mmaa x 1890,RZM 1890	17214	57.61	14.9	---	1.4	126	83.1	5.3
2867m	1867,1867Raa x A	17229	57.67	15.0	---	0.6	126	83.5	7.0
2865m	RZM 1865-#,1865aa x A	17044	54.60	15.6	---	0.7	123	81.8	6.8
Mean		18561.5	59.43	15.6	---	0.3	124.3	83.4	5.1
LSD (.05)		1738.0	4.80	0.7	---	1.2	11.3	2.6	0.9
C.V. (%)		8.1	6.98	4.1	---	368.0	7.9	2.7	15.3
F value		4.1**	3.88**	2.1*	---	1.2NS	6.4**	0.8NS	8.7**

[4]0915-#'s & 2915-# = progeny lines from popn-915. 0790, 2890, 2867, & 2865 = mm, S^f, A:aa popns.
[5]Powdery mildew scored 9/14/93 and 9/27/93 on a scale of 0 to 9 where 9 = severe mildew.

TEST 893. YIELD EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993

64 entries x 6 reps, RCB; 4 sets with 16 entries each in incomplete blocks
1-row plots, 20 ft. long
4 sets with 16 entries each in incomplete blocks

Planted: February 16, 1993
Harvested: October 12-13, 1993

Variety[2]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew Mean[1]	RJAP %
Set 1 (893-1) MM,O.P. Lines									
268	Increase 768 (US 75)	15128	56.63	13.4	0.0	1.2	140	4.8	80.6
U86-37	Inc. C37, 86443	14667	51.45	14.2	0.0	0.0	133	6.0	82.4
R279	RZM R079, (C37Rz)	17241	60.24	14.3	0.0	0.0	144	4.4	82.3
R279Y	RZM-BYV-ER R079	16495	55.09	15.0	0.5	0.0	142	4.8	83.0
R279R2	RZM 1204-#(C)	16833	58.24	14.4	0.0	0.6	135	6.3	82.1
R128	RZM 0271-#, (C28)	17203	59.08	14.6	6.2	2.5	138	6.3	82.4
R228	RZM 1202-#(C)	15811	52.78	15.0	2.1	0.6	147	6.7	83.5
R230	RZM R130	18025	63.56	14.2	6.7	0.6	138	4.0	83.7
R232	RZM 1201-#(C)	16059	58.52	13.7	14.8	0.0	136	6.0	83.0
R204	RZM R104	17925	66.78	13.4	19.7	0.0	138	5.1	85.4
P201	PMR 1211,...,1216	15439	51.80	14.9	17.3	0.6	139	3.4	82.0
P202	PMR 1217,...,1224	17106	58.17	14.7	9.5	0.0	139	4.3	83.2
U86-46/2	Inc. C46/2, 86342	18434	60.90	15.1	0.0	0.0	127	3.2	82.7
R278	RZM R078, (C46/2Rz)	19110	61.29	15.6	0.0	0.6	141	3.8	84.0
R278Y	RZM-BYV-ER R078	19079	62.16	15.3	0.0	0.6	143	3.9	84.3
US H11	L113401	18397	62.86	14.6	0.0	0.0	135	6.8	82.8
Mean		17059.6	58.72	14.5	4.8	0.5	138.3	5.0	83.0
LSD (.05)		2089.4	5.61	0.9	4.1	1.4	10.6	1.0	2.8
C.V. (%)		10.7	8.30	5.6	74.2	273.1	6.7	18.0	2.9
F value		3.5**	4.80**	4.0**	22.6**	1.6NS	1.7NS	11.0**	1.2NS

Note: Tests 693-1293 were grown under nondiseased or controlled conditions. There was no evidence of rhizomania. Virus yellows and other diseases were mild. Root rot primarily due to Erwinia.

[1]Powdery mildew scored 9/14 & 9/21/93 on a scale of 0 to 9 where 9 = 90-100% of mature leaf area covered with mildew. Earlier in season, PM had been very well controlled with Bayleton.

[2]See Test 1493. R204 = rhizomania resistant selection within an accession from Italy with weed beet traits. R232 = F_2(C37 x R04).

TEST 893. YIELD EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993

(cont.)

Variety[2]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew Mean[1]	RJAP %
Set 2 (893-2) MM,O.P. Lines									
Rhizoguard	L893301	18253	60.58	15.1	0.0	1.3	126	5.5	85.5
Y954	Inc. Y854	17987	57.68	15.6	0.0	0.0	126	3.4	84.7
Y054	BYR-ER-PMR Y854, (C54)	20775	64.12	16.2	0.0	0.0	136	3.3	84.8
R280	RZM R080, (C54Rz)	18380	59.84	15.4	0.0	0.6	140	4.1	83.5
R280Y	RZM-BYV-ER R080	19949	65.52	15.2	0.0	0.0	136	4.6	83.5
R280- 1	Inc. R080- 1	18940	59.85	15.8	0.0	0.0	143	4.1	83.2
R280-13	Inc. R080-13	19518	61.74	15.8	0.0	0.0	137	2.3	82.4
R280-28	Inc. R080-28	18498	58.59	15.8	0.0	0.0	135	3.9	81.9
R280-35	Inc. R080-35	18425	56.42	16.3	0.0	2.4	142	3.6	83.3
R280-45	Inc. R080-45	19783	62.51	15.8	0.0	0.0	154	3.0	83.5
R280-56	Inc. R080-56	18974	62.09	15.3	0.0	0.0	140	2.9	82.8
R280-79	Inc. R080-79	18428	57.26	16.1	0.0	0.0	136	3.3	83.4
R280-80	Inc. R080-80	19386	62.79	15.4	0.6	0.0	138	2.5	84.4
R122R3	RZM R022R2	17600	62.12	14.2	5.3	3.1	149	5.4	80.3
R222R4	RZM R122R3	17577	62.79	14.0	7.7	1.2	131	5.8	80.5
R122Y2	BYR R922Y	18433	59.85	15.4	0.0	1.8	138	4.1	83.9
Mean		18806.6	60.86	15.5	0.9	0.6	137.9	3.9	83.2
LSD (.05)		1754.0	4.67	0.7	1.8	1.7	14.0	1.0	2.2
C.V. (%)		8.1	6.67	3.7	183.0	236.4	8.8	23.4	2.3
F value		2.0*	2.37**	7.7**	12.5**	2.6**	2.2*	7.9**	3.2**

[2]See Test 1493. R222R4 = cycle 4 synthetic from F_3 (Y54 x B.maritima).

TEST 893. YIELD EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993

(cont.)

Variety[2]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew Mean[1]	RJAP %
Set 3 (893-3) MM,O.P. Lines									
6770	high % S check (Beta)	19704	57.47	17.2	0.6	0.6	144	4.7	83.7
R270Y	RZM-BYV-ER R070	18864	60.55	15.6	0.0	0.0	141	3.6	83.9
F86-31/6	Inc. C31/6, L86263	18225	57.75	15.8	0.0	0.7	136	3.8	83.6
R276	RZM R076, (C31/6Rz)	18501	64.54	14.3	1.1	0.6	148	4.0	83.7
R276Y	RZM-BYV-ER R076	19064	62.65	15.2	0.0	0.0	141	4.9	84.3
Y231-43	Inc. Y131-43 (C31-43)	21088	66.01	16.0	0.0	0.0	138	3.0	84.0
R276-43	RZM R176-43	21319	68.25	15.6	0.0	0.0	143	3.7	84.6
R281-43	Y131-43 x RZM R176-43,-89	21850	70.70	15.5	0.8	0.0	83	3.8	83.1
R281-89	Y131-89 x RZM R176-43,-89	18089	57.80	15.7	0.0	2.1	106	3.3	84.4
R276-89	RZM R176-89	18868	62.71	15.1	0.0	0.0	138	3.3	82.9
Y231-89	Inc. Y131-89, (C31-89)	18715	60.90	15.4	0.0	0.6	139	3.8	83.1
R282	Inc. R176-43,-89	19516	65.87	14.8	1.2	0.0	125	3.8	82.5
R283	rr(C) x R(C) composite cross	19934	64.61	15.4	0.0	0.0	137	4.0	83.2
Y141	BYR Y841, (C91)	18463	57.82	16.0	0.0	0.6	149	1.2	83.1
Y049	BYR-ER-PMR Y849, (C49)	18785	59.36	15.8	0.0	0.6	130	1.2	84.6
HH 41	L412307	19661	67.34	14.6	0.0	0.0	134	4.9	84.3
Mean		19415.4	62.77	15.5	0.2	0.4	133.2	3.5	83.7
LSD (.05)		2093.4	6.00	0.8	1.0	1.4	11.1	1.0	2.1
C.V. (%)		9.4	8.31	4.5	370.0	344.5	7.3	23.7	2.2
F value		2.3**	3.86**	5.5**	1.5NS	1.2NS	18.5**	9.9**	0.8NS

[2]See Test 1493.

TEST 893. YIELD EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993
(cont.)

Variety[2]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew Mean[1]	RJAP %
Set 4 (893-4) MM,O.P. Lines									
US H11	L113401	18030	59.95	15.0	0.0	1.3	136	6.8	84.4
Rhizosen	L493304	19039	65.38	14.6	0.0	2.4	144	5.3	84.7
Rima	RN3-1021 rec'd 1/93	21243	64.47	16.5	0.0	0.0	141	4.0	83.9
Y439	CO, Inc. Y339	16972	53.36	15.9	1.1	0.7	132	2.3	83.5
R039C5	C5, Inc. R939C5, (C39R)	17456	56.53	15.4	2.6	0.0	128	2.3	84.9
R139C7	C7, RZM R039C6	19311	62.16	15.6	0.0	0.6	143	3.0	83.1
R239C8	C8, RZM R139C7	19754	64.04	15.4	0.0	4.3	138	1.6	84.0
Y139	YR, BYR Y939, (C39)	17864	54.85	16.3	0.0	0.7	125	0.8	84.0
Y547	CO, YR-ER-PMR Y347	18467	59.21	15.6	0.0	0.0	128	3.5	82.5
R047C5	C5, Inc. R947C5, (C47R)	19203	62.51	15.4	0.6	0.0	128	4.4	82.8
R147C7	C7, RZM R047C6	18222	61.04	14.9	0.0	0.0	139	5.2	83.3
R247C8	C8, RZM R147C7	19913	64.19	15.5	0.0	0.0	142	4.9	84.0
Y147	YR, BYR Y947, (C47)	19674	61.32	16.0	0.0	0.0	138	3.1	83.1
R207	RZM R107	17747	58.73	15.1	0.0	0.0	140	6.1	84.0
R208	RZM R108	18944	62.79	15.1	0.0	0.0	143	4.4	82.8
2915	RZM 1915-S_1,1913-S_1 x A	19171	64.61	14.8	0.0	0.0	131	3.5	84.2
Mean		18813.2	60.95	15.5	0.3	0.6	135.8	3.8	83.7
LSD (.05)		1977.4	5.72	0.8	1.3	1.6	11.7	1.1	2.0
C.V. (%)		9.1	8.16	4.3	412.5	229.8	7.5	24.4	2.1
F value		2.4**	3.18**	3.9**	2.3**	4.1**	2.5**	18.6**	1.0NS

[2]See Test 1493.

TEST 893. YIELD EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993
64 entries x 6 reps, RCB; 1-row plots, 20 ft. long. ANOVA to compare means across sets.

Mean	18523.7	60.82	15.2	1.5	0.5	136.3	4.1	83.4
LSD (.05)	2039.5	5.64	0.8	2.4	1.6	11.9	1.1	2.3
C.V. (%)	9.7	8.16	4.8	136.2	265.2	7.7	23.1	2.4
F value	3.8**	3.76**	6.2**	22.3**	2.4**	5.6**	12.6**	1.6**

TEST 1093. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES FROM POPN-864 AND R080, SALINAS, CA., 1993

32 entries x 8 replications, RCB (equalized)
1-row plots, 30 ft. long

Planted: February 2, 1993
Harvested: September 21-23, 1993

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew[2] Mean	RJAP %
Checks									
6770	High % S check (Beta)	19072	56.42	16.9	0.0	0.6	142	4.9	84.0
4757	Beta (1/6/89)	18423	63.60	14.5	0.0	0.0	145	3.8	83.4
Rhizoguard	L899301	17814	60.58	14.7	0.6	0.3	141	6.5	84.6
Topcross Hybrids									
R282H20	87-309H3 x R176-43,-89	18577	63.63	14.6	1.7	0.3	139	6.1	83.2
2911-4H20	87-309H3 x RZM 1911-4	18257	60.76	15.0	0.0	0.0	134	6.4	83.1
2915H20	87-309H3 x 1913,1915	18161	62.37	14.6	0.3	0.0	144	7.0	82.9
R280H39	C762-17CMS x R080	17839	65.17	13.7	0.3	0.0	139	5.3	83.7
R276H20	87-309H3 x R076	17816	61.99	14.4	0.3	0.0	139	6.6	83.7
R280H8	F82-546H3 x R080	17601	61.28	14.4	0.6	0.3	144	6.4	84.1
R278H20	87-309H3 x R078	17564	59.82	14.7	1.5	0.0	144	7.2	83.4
R222R4H20	87-309H3 x RZM R122R3	16686	59.47	14.0	6.4	0.0	136	7.8	82.3
N203H20	87-309H3 x N103,N103-1	14747	62.35	11.8	0.3	8.3	139	8.8	82.3
R080 Progenies									
R280-79H20	87-309H3 x R080-79	18856	62.58	15.1	0.0	0.0	137	6.5	83.4
R280-1H20	87-309H3 x R080-1	18816	63.10	14.9	0.0	0.5	142	6.8	83.3
R280-28H20	87-309H3 x R080-28	18815	62.96	15.0	0.0	0.3	124	5.7	83.7
R280-45H20	87-309H3 x R080-45	18760	61.43	15.3	0.3	0.0	140	6.3	83.9
R280-13H20	87-309H3 x R080-13	18681	63.56	14.7	0.0	0.0	137	6.1	83.4
R280-35H20	87-309H3 x R080-35	18626	62.26	15.0	0.0	0.0	125	6.6	83.3
R280-80H20	87-309H3 x R080-80	18344	62.21	14.8	0.0	0.3	135	6.1	83.3
R280H20	87-309H3 x R080 (Iso)	18342	61.53	14.9	0.3	0.3	141	6.8	83.5
R280-56H20	87-309H3 x R080-56	17544	59.90	14.7	0.0	0.0	131	6.3	82.9

TEST 1093. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES FROM POPN-864 AND R080, SALINAS, CA., 1993 (cont.)

Variety[1]	Description	Acre Yield Sugar	Acre Yield Beets	Sucrose	Bolters	Root Rot	Beets/ 100'	Powdery Mildew[2]	RJAP
		Lbs	Tons	%	%	%	No.	Mean	%
Popn-864 Progenies									
R280H62-14	0864-14aa x R080	19361	66.40	14.6	0.6	0.3	137	4.8	84.8
R280H62- 8	0864- 8aa x R080	19133	66.08	14.5	0.5	0.0	128	5.6	83.0
R280H62-34	0864-34aa x R080	18920	65.66	14.4	1.9	0.9	131	5.6	83.9
R280H68	1867Raa x R080	18743	65.52	14.3	1.0	0.3	136	6.0	83.8
R280H62-40	0864-40aa x R080	18691	65.28	14.3	1.2	0.0	132	6.0	83.8
R280H62-25	0864-25aa x R080	18352	62.75	14.6	0.3	0.4	119	4.6	83.4
R280H62-19	0864-19aa x R080	18284	61.74	14.8	2.2	0.3	134	6.2	84.4
R280H64	1864aa x R080	18154	64.30	14.1	0.3	0.0	126	6.0	83.4
R280H62- 1	0864- 1aa x R080	18122	62.86	14.4	0.0	1.5	138	5.1	84.0
R280H62-28	0864-28aa x R080	18014	62.16	14.5	1.1	0.0	114	5.1	83.9
R280H62- 5	0864- 5aa x R080	17880	60.63	14.7	0.4	2.2	119	5.3	83.9
Mean		18218.5	62.51	14.6	0.7	0.5	134.7	6.1	83.6
LSD (.05)		854.2	3.86	0.5	1.2	1.6	12.6	0.6	1.6
C.V. (%)		6.7	6.26	3.3	180.9	299.3	9.5	10.8	1.9
F value		3.8**	2.43**	18.1**	7.6**	6.9**	3.0**	17.2**	1.0NS

[1]F82-546H3 = C562CMS x C546. 87-309H3 = C562CMS x C309. 1864 & 1867R are S^f,A:aa,R_z populations. 0864-#'s are progeny families selected from popn-864 on the basis of per se performance for components of yield and resistance to rhizomania. R080 = MM,R_z line. R080-#'s are progeny families selected from line R80 on the basis of per se performance under virus yellows, rhizomania, and bolting conditions. R076, R078, and R176-43, -89 are MM, R_z lines. R176-43 & -89 are similar to C76-43 & C76-89 combined. 1913/1915 is a S^f,MM,R_z population. Increase of 1911-4 was released as C911-4. R122R3 is 50% Beta maritima population. N103/N103-1 = C603/C603-1.

[2]Powdery mildew scored on 9/15/93 and 9/21/93. Test was treated with Bayleton for PM control. Development of PM was late and had minimal effect on yield.

Note: Agronomically test was very good. BWYV occurred. Some plants were infected with Erwinia. Nitrogen status was high at time of harvest. Rhizomania or cyst nematodes were not detected.

TEST 1293. EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1993

32 entries x 8 replications, RCB (equalized)
1-row plots, 30 ft. long

Planted: February 2, 1993
Harvested: September 20-22, 1993

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew[2] Mean	RJAP %
Checks and Nema Resist.									
6770	High % S check (Beta)	18631	57.15	16.3	0.0	0.3	141	4.9	83.8
Rhizoguard	L893301	15857	55.19	14.4	1.0	0.6	134	6.3	82.8
N203H18	88-790-68H26 x N103,N103-1	14483	58.49	12.4	0.0	4.4	130	8.0	80.3
Topcross Hybrids									
R280H90	C790aa x R080	18939	66.61	14.3	0.7	1.0	136	5.2	83.3
R280H52	1852-7HO x R080	18193	63.62	14.3	0.0	0.0	127	4.9	83.5
R280H39	C762-17CMS x R080	17918	66.32	13.5	0.3	0.0	139	5.0	82.5
R280H18	88-790-68H26 x R080	17782	60.44	14.8	0.6	0.0	144	5.3	81.8
R280H65	1865aa x R080	17602	59.60	14.8	0.3	0.3	139	5.7	82.4
R280H68	1867Raa x R080	17529	62.83	13.9	1.8	0.0	135	5.4	82.5
R280H51	1855-59HO x R080	17501	60.44	14.5	0.0	0.0	144	5.9	81.4
R280H33	C790-54aa x R080	17468	61.75	14.2	0.0	0.0	132	4.3	82.2
R280H20	87-309H3 x R080	17457	59.74	14.6	0.9	0.0	149	6.3	81.8
R280H29	C790-6aa x R080	17439	63.63	13.7	0.0	0.9	129	6.2	81.8
R280H64	1864aa x R080	17380	62.97	13.8	0.9	0.0	134	5.8	83.1
R280H97	C796-43HO x R080	17378	61.28	14.2	0.0	0.0	141	6.0	82.2
R280H36	0833HO x R080	17183	62.37	13.8	0.3	0.0	139	6.0	82.2
R280H58	1859Raa x R080	17161	62.06	13.9	0.7	0.0	131	6.2	82.5
R280H93	1890aa x R080	17057	59.33	14.4	0.0	0.0	141	5.6	83.4
R280H22	0722HO x R080	16965	60.06	14.1	0.0	0.0	135	6.0	82.3
R280H92	C796-22HO x R080	16633	59.08	14.1	0.3	0.3	130	5.7	82.4
R280H53	1852-52HO x R080	15758	55.39	14.2	0.0	0.0	131	5.7	82.8

TEST 1293. EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1993
(cont.)

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew[2] Mean	RJAP %
Population Hybrids									
2915H39	C762-17CMS x RZM 1913,1915	18690	70.70	13.2	0.0	0.0	139	4.9	81.7
2915H90	C790aa x RZM 1913,1915	18643	67.44	13.9	0.0	0.0	144	4.9	82.1
2915H68	1867Raa x RZM 1913,1915	18500	66.43	13.9	0.0	0.0	137	5.6	82.1
2915H58	1859Raa x RZM 1913,1915	17713	61.88	14.3	0.0	0.0	138	6.1	83.0
2915H18	88-790-68H26 xRZM 1913,1915	17327	60.38	14.4	0.3	0.0	144	5.6	82.2
2915H65	1865aa x RZM 1913,1915	17238	60.86	14.2	0.0	0.0	134	6.1	82.0
2867H15	1915aa x 1867,1867R	17818	62.58	14.2	0.3	0.0	137	5.3	83.1
2865H15	1915aa x 1865,1865-#	17742	61.95	14.3	0.3	0.0	146	6.2	82.5
2890H15	1915aa x 1890,RZM 1890	17465	61.64	14.2	0.0	0.9	135	5.4	82.8
2859H15	1915aa x 1859,1859R	16996	60.90	14.0	0.0	0.6	134	6.0	83.1
N203H15	1915aa x N103,N103-1	15765	64.33	12.3	0.0	0.9	139	7.9	80.6
Mean		17381.5	61.80	14.1	0.3	0.3	137.1	5.8	82.4
LSD (.05)		1246.5	4.13	0.5	0.8	1.1	9.0	0.6	1.3
C.V. (%)		7.3	6.79	3.3	288.5	336.9	6.6	11.3	1.6
F value		4.4**	5.03**	17.3**	2.3**	4.6**	2.7**	10.8**	2.7**

[1]R080 = MM,R_z line. 1913/1915 = S^f,MM,A:aa,R_z population similar to C918. 1859R is similar to C859. 1890 is similar to C890. N103/N103-1 = C603/C603-1. 1867, 1865, & 1864 are S^f,A:aa,R_z populations. 790-68H26 = C309CMS x C790-68. 309H3 = C562CMS x C309.

[2]Powdery mildew scored on 9/09/93 and 9/15/93. Test was treated with Bayleton for PM control. Development of PM was late and had minimal effect on yield.

TEST 1193. AREA 4 CODED VARIETY TRIAL, SALINAS, CA., 1993

32 entries x 8 replications, RCB (equalized)
1-row plots, 30 ft. long

Planted: February 2, 1993
Harvested: September 27-28, 1993

Code	Variety[1]	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	Bolters %	PM Score Mean[2]
CBGA Entries									
2	Beta 4757	Betaseed	19359	64.12	15.1	139	0.3	0.0	3.3
7	HH 66	Holly	18542	61.25	15.1	137	0.3	0.0	6.0
4	93HX2	Holly	18371	59.29	15.5	143	0.0	0.0	4.9
18	HH 37	Holly	18426	63.07	14.6	126	0.6	0.3	5.1
16	Beta 4454	Betaseed	18405	60.21	15.3	147	0.3	0.0	3.1
5	91C 143-07	Holly	17931	56.03	16.0	142	0.0	0.0	5.0
15	SS-242	Spreckels	18032	58.14	15.5	146	0.0	0.0	5.6
3	SS-287R	Spreckels	18066	61.04	14.8	146	0.6	0.0	5.4
12	SS-289R	Spreckels	18026	58.45	15.4	142	1.0	0.0	6.1
13	93HX8	Holly	17795	58.45	15.2	139	0.9	0.0	5.3
1	93HX20	Holly	17841	57.08	15.6	146	0.6	0.3	4.9
6	Hill 2	Hill Mono-Hy	18147	58.57	15.5	142	0.3	0.0	4.4
14	Beta 4783	Betaseed	17767	58.69	15.1	147	0.0	0.0	4.0
8	SS-NB2	Spreckels	17696	57.99	15.3	140	0.0	0.0	5.3
10	SS-NB3	Spreckels	17623	59.01	14.9	139	0.9	0.0	5.6
9	93HX9	Holly	17172	55.02	15.6	144	0.9	0.0	7.0
11	93HX12	Holly	17066	57.99	14.7	139	0.6	0.0	6.2
17	Beta 4581	Betaseed	16428	55.65	14.8	144	1.5	0.3	3.7
USDA Entries		Description							
23	R282H18	88-790-68H26 x R176-43,-89	19445	64.33	15.1	139	1.7	0.6	4.6
22	R280H18	88-790-68H26 x R080	19278	62.47	15.4	144	0.3	1.4	5.4
27	2915H39	C762-17CMS x 1915	19635	70.32	14.0	142	0.0	0.0	4.1
25	R278H39	C762-17CMS x R078	19198	64.57	14.9	140	0.9	2.7	4.1
31	R280H3	C790-54aa x R080	19409	66.57	14.6	135	0.0	0.6	3.9

TEST 1193. AREA 4 CODED VARIETY TRIAL, SALINAS, CA., 1993
(cont.)

Code	Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Root Rot %	Bolters %	PM Score Mean[2]
USDA Entries (cont.)									
30	R280H89	C790-68CMS x R080	18945	61.85	15.3	141	2.4	0.6	4.3
29	R280H20	87-309H3 x R080	18773	62.02	15.1	144	0.3	0.3	5.6
21	R278H18	88-790-68H26 x R078	18344	59.50	15.4	147	0.9	0.8	5.5
28	2915H20	87-309H3 x 1915	18639	62.79	14.9	139	0.0	0.3	6.0
26	R280H39	C762-17CMS x R080	18489	65.31	14.2	144	1.2	0.3	5.1
32	R280H90	C790aa x R080	18204	62.47	14.6	138	0.0	0.0	4.1
20	R276H18	88-790-68H26 x R076	18216	62.37	14.6	149	0.0	1.5	4.9
24	2915H18	88-790-68H26 x 1915	18182	60.65	15.0	138	0.0	0.0	5.6
19	6770	High % S check	17458	52.01	16.8	144	0.3	0.0	4.9
Mean			18278.4	60.54	15.1	141.6	0.5	0.3	5.0
LSD (.05)			1322.4	4.32	0.4	11.4	1.2	0.9	0.7
C.V. (%)			7.3	7.25	3.0	8.2	230.3	288.0	14.6
F value			2.4**	5.69**	11.2**	1.2NS	1.9**	3.5**	12.1**

Test was grown in a field plot area that had not been in sugarbeets for more than 20 years. There was no evidence of rhizomania or cyst nematode. Some Erwinia root rot occurred, having spread from Erwinia inoculated tests. BWYV was evident in early June. Bayleton was used to control powdery mildew, and powdery mildew did not develope until September. 60 to 70 ton yields were common in this and adjacent USDA tests. At harvest, beets were still growing rapidly and needed 4-6 weeks more to use available nitrogen and fully exploit growing season, so that respectivle yields could be achieved.

[1]790-68H26 = C309CMS x C790-68. 309H3 = C562CMS x C309. R176-43,-89 is unselected version of C76-43,-89. 1915 is similar to C918. R076, R078, and R080 are near-isogenic Rz_ lines of C31/6, C46/2, and C54.

[2]Powdery mildew was scored on a scale of 0 to 9, where 9 = severe infection. Scores were taken on 9/9/93 and 9/15/93.

TEST 1193. AREA 4 CODED VARIETY TRIAL, SALINAS, CA., 1993

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH_2-N ppm	Impur. Value
CBGA Entries									
2	Beta 4757	17611	274	90.9	1748.3	488	1906	280	9130
7	HH 66	16969	277	91.5	1572.8	364	1706	317	8551
4	93HX2	16958	286	92.3	1413.3	351	1598	285	7932
18	HH 37	16893	268	91.7	1533.7	365	1703	272	8118
16	Beta 4454	16639	277	90.3	1766.6	488	2133	297	9859
5	91C 143-07	16611	297	92.6	1320.1	377	1626	268	7927
15	SS-242	16565	285	91.8	1467.6	370	1659	319	8472
3	SS-287R	16478	271	91.2	1588.1	373	1800	300	8653
12	SS-289R	16454	281	91.1	1571.5	346	1884	336	9107
13	93HX8	16428	281	92.3	1366.9	396	1514	280	7830
1	93HX20	16329	286	91.5	1512.0	472	1974	244	8900
6	Hill 2	16324	279	90.0	1822.5	411	2122	383	10376
14	Beta 4783	16131	275	90.8	1635.9	480	1996	282	9345
8	SS-NB2	16037	277	90.6	1659.7	318	1862	398	9543
10	SS-NB3	15979	271	90.6	1644.2	388	1854	360	9409
9	93HX9	15762	287	91.8	1409.7	373	1857	272	8525
11	93HX12	15438	267	90.5	1627.4	417	1991	309	9368
17	Beta 4581	14732	265	89.7	1696.5	489	2217	308	10176
USDA Entries									
23	R282H18	17648	275	90.8	1796.5	379	1966	323	9305
22	R280H18	17641	283	91.5	1636.7	303	1769	344	8752
27	2915H39	17593	250	89.5	2042.0	426	2259	275	9754
25	R278H39	17327	269	90.2	1871.1	402	2124	311	9670
31	R280H33	17238	260	88.9	2171.4	475	2068	421	10826

TEST 1193. AREA 4 CODED VARIETY TRIAL, SALINAS, CA., 1993

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH_2-N ppm	Impur. Value
USDA Entries (cont.)									
30	R280H89	17204	279	90.9	1741.6	392	2150	272	9331
29	R280H20	16868	272	89.9	1904.8	425	2116	365	10246
21	R278H18	16828	283	91.7	1516.0	292	1732	342	8602
28	2915H20	16721	267	89.7	1917.4	388	2179	357	10193
26	R280H39	16555	254	89.6	1933.6	449	2170	289	9742
32	R280H90	16412	263	90.2	1792.3	478	2000	300	9526
20	R276H18	16328	262	89.7	1888.2	470	2045	341	9994
24	2915H18	16298	269	89.6	1884.1	407	2286	337	10340
19	6770	16212	312	92.8	1245.4	463	1756	213	8034
Mean		16600.3	275.0	90.8	1678.1	406.6	1938.1	312.3	9235.5
LSD (.05)		1288.9	10.9	1.9	342.7	174.2	456.5	102.2	1792.6
C.V. (%)		7.9	4.0	2.1	20.7	43.5	23.9	33.2	19.7
F value		2.0**	9.7**	2.3**	3.1**	0.8NS	1.6NS	1.5NS	1.6NS

TEST 993. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES FROM POPNS-911,-913,-915, SALINAS, CA., 1993

48 entries x 8 replications, RCB (equalized); 3 sets, 16 x 8 (equalized) Planted: February 16, 1993
1-row plots, 20 ft. long Harvested: October 19-20, 1993

Variety[1]	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot[3] %	Beets/ 100' No.	Powdery Mildew[4] Mean	RJAP %
Set 1: 16 varieties x 8 reps (RCB)								
2915H20	87-309H3 x RZM 1913,1915	17351	57.26	15.2	0.0	92	6.9	82.5
0909-34H20	87-309H3 x 8909A-34	18806	59.03	15.9	0.0	122	6.3	83.7
0909-37H20	87-309H3 x 8909A-37	19004	59.33	16.0	0.0	126	5.4	84.1
2911-4H20	87-309H3 x RZM 1911-4	18294	55.23	16.6	0.0	129	6.3	84.1
2911-12H20	87-309H3 x RZM 1911-12	20107	63.53	15.9	0.0	127	6.3	83.0
2911-14H20	87-309H3 x RZM 1911-14	19604	61.20	16.1	0.0	126	6.5	84.0
2911-50H20	87-309H3 x RZM 1911-50	19632	63.74	15.4	0.0	131	6.4	82.3
2913-5H20	87-309H3 x RZM 1913-5	17908	60.11	14.9	0.5	132	6.8	83.1
2913-18H20	87-309H3 x RZM 1913-18	18610	59.27	15.7	0.0	123	6.4	84.8
2913-22H20	87-309H3 x RZM 1913-22	20143	64.58	15.6	0.5	128	5.9	83.1
2913-25H20	87-309H3 x RZM 1913-25	20172	64.21	15.7	0.0	126	5.9	83.8
2911-24H20	87-309H3 x 0911-24	17610	57.83	15.3	3.1	127	6.9	83.2
2913-9H20	87-309H3 x 0913-9	18458	58.79	15.7	0.0	125	6.6	82.8
2915-4H20	87-309H3 x 0915-4	18271	59.11	15.4	0.5	128	6.5	83.5
2915-7H20	87-309H3 x 0915-7	20152	63.63	15.8	0.0	130	6.9	83.8
2915-46H20	87-309H3 x 0915-46	19464	61.79	15.8	0.0	128	6.6	83.3
Mean		18974.1	60.54	15.7	0.3	125.0	6.4	83.4
LSD (.05)		1375.8	4.40	0.5	1.5	10.2	0.7	1.7
C.V. (%)		7.3	7.34	3.4	539.5	8.3	10.6	2.1
F value		3.7**	3.18**	4.6**	2.0*	6.4**	2.9NS	1.1NS

TEST 993. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES FROM POPNS-911,-913,-915, SALINAS, CA., 1993
48 entries x 8 replications, RCB (equalized). ANOVA to compare means across sets of entries.

Mean	18576.6	59.53	15.6	0.4	122.1	6.2	83.2
LSD (.05)	1609.9	4.95	0.6	1.8	12.3	0.7	1.8
C.V. (%)	8.8	8.39	3.7	478.2	10.2	11.2	2.2
F value	3.4**	3.68**	7.2**	1.8**	3.9**	3.3**	1.6*

TEST 993. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES FROM POPNS-911,-913,-915, SALINAS, CA., 1993 (cont.)

Variety[2]	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot[3] %	Beets/ 100' No.	Powdery Mildew[4] Mean	RJAP %
Set 2: 16 varieties x 8 reps (RCB)								
US H11	L113401	16014	54.25	14.8	0.0	116	7.1	83.1
2915H65	1865aa x RZM 1913,1915	19988	65.57	15.2	0.0	129	6.9	83.4
2865H13	1913aa x 1865,1865-#	19213	62.78	15.3	0.0	117	6.4	83.7
2865H43-4	1911-4aa x 1865,1865-#	16518	54.55	15.2	0.9	90	6.3	82.1
2865H43-12	1911-12aa x 1865,1865-#	19505	62.59	15.6	0.0	117	6.0	82.5
2865H43-14	1911-14aa x " "	18977	60.43	15.8	0.5	125	5.9	82.2
2865H43-50	1911-50aa x " "	17220	57.03	15.1	0.0	112	5.9	81.9
6770	High % Sugar check	18937	51.20	18.5	1.1	129	6.3	85.0
Rhizoguard	L893301	15739	51.46	15.3	4.3	103	7.1	84.1
2865H45- 5	1913- 5aa x 1865,1865-#	18862	60.22	15.7	0.6	125	6.1	83.3
2865H45-18	1913-18aa x " "	18893	58.61	16.1	0.0	123	5.8	83.4
2865H45-22	1913-22aa x " "	18815	60.24	15.6	0.0	116	6.1	83.5
2865H45-25	1913-25aa x 1865,1865-#	18365	58.71	15.7	0.0	124	5.9	83.3
2865H46- 1	0911- 1aa x " "	19769	64.44	15.4	0.0	120	5.6	81.8
2865H46-4B	0911-4(B)aa x "	17517	54.51	16.1	0.5	111	6.0	83.4
2865H46-24	0911-24aa x " "	18308	59.48	15.4	1.6	126	6.4	83.2
Mean		18289.9	58.51	15.7	0.6	117.7	6.2	83.1
LSD (.05)		1798.6	5.39	0.6	2.6	14.6	0.4	1.8
C.V. (%)		9.9	9.31	3.7	450.4	12.6	7.3	2.2
F value		4.2**	5.14**	16.5**	1.4NS	3.8**	7.7*	1.7NS

[1]Evaluation of progeny families from MM,S^f,A:aa,Rz populations 909,911,913, and 915. Progenies were previously tested per se and in testcross hybrids under nondiseased and diseased (rhizomania, BYV/BWYV, bolting, Erwinia, powdery mildew, etc.) conditions and selected on the basis of these tests. Increases of lines 8909-34, 8909-37, 1911-4, 1911-12, 1911-14, and 1911-50 were released in 1993 as C909-34, C909-37, C911-4, C911-12, C911-14, and C911-50.

[2]Topcross hybrids of selected progeny families where 1865 tester is a mm,S^{f}A:aa,Rz population similar to C310. 2915H65 and 2865H13/2865H15 would be reciprocal population hybrids. See test 1793 for the same entries under BYV/BWYV inoculated conditions.

TEST 993. EVALUATION OF HYBRIDS FROM SELECTED PROGENY FAMILIES FROM POPNS-911,-913,-915, SALINAS, CA., 1993 (cont.)

Variety[2]	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot[3] %	Beets/ 100' No.	Powdery Mildew[4] Mean	RJAP %
Set 3: 16 varieties x 8 reps (RCB)								
Rhizosen	L493304	18084	60.00	15.1	2.7	131	6.4	85.1
2915H65	1865aa x RZM 1913,1915	19296	63.68	15.2	0.0	126	5.9	83.8
2865H15	1915aa x 1865,1865-#	19684	63.74	15.5	0.0	127	5.4	83.1
2865H47-6	0913-6aa x 1865,1865-#	18131	57.03	15.9	0.0	117	5.4	83.0
2865H47-9	0913-9aa x 1865,1865-#	19096	61.46	15.6	0.0	126	6.1	82.5
2865H48-1	0915-1aa x " "	17352	56.33	15.4	0.0	118	6.1	83.2
2865H48-4	0915-4aa x " "	17004	56.51	15.0	0.0	119	6.1	82.0
2865H48-6	0915-6aa x " "	18396	57.86	15.9	0.0	128	5.8	83.1
2865H48- 7	0915- 7aa x 1865,1865-#	17830	56.70	15.7	1.5	125	6.1	81.8
2865H48-16	0915-16aa x " "	18800	59.75	15.8	0.0	126	5.6	83.1
2865H48-22	0915-22aa x " "	17444	55.49	15.8	0.0	123	5.9	83.5
2865H48-23	0915-23aa x " "	18497	59.16	15.6	0.0	123	5.7	83.6
2865H48-24	0915-24aa x 1865,1865-#	18794	61.37	15.3	0.0	121	6.2	82.5
2865H48-27	0915-27aa x " "	19276	61.06	15.8	0.0	124	6.0	83.8
2865H48-34	0915-34aa x " "	18991	61.12	15.6	0.0	124	6.8	82.8
2865H48-46	0915-46aa x " "	18777	61.26	15.3	0.5	121	5.6	81.4
Mean		18465.9	59.53	15.5	0.3	123.6	5.9	83.0
LSD (.05)		1506.8	4.44	0.5	1.1	9.4	0.7	1.7
C.V. (%)		8.2	7.54	3.5	418.1	7.7	11.6	2.1
F value		2.1NS	2.73*	2.3NS	3.0**	1.3NS	2.1NS	2.1*

[3]Root rot to Erwinia.
[4]Powdery mildew scored 9/14/93 and 9/21/93 on a scale of 0 to 9 where 9 = 90-100% of the leaf area covered with mildew.

TEST 1493. VIRUS YELLOWS EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993

48 entries x 6 replications, RCB
1-row plots, 20 ft. long
4 sets with 12 entries each in incomplete blocks

Planted: March 9, 1993
Harvested: October 25-26, 1993
BYV/BWYV Inoc.: May 6, 1993[1]

Variety[5]	Description	Acre Yield Relative[2] %	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolting %	Root Rot %	Beets/ 100' No.	Powdery Mildew[3] Mean	RJAP %	Virus Yellows[4] Mean
Set 1 (1493-1) MM,O.P. Lines											
268	Inc. 768 (US 75)	40.4	6108	23.04	13.2	0.0	0.6	137	8.8	78.0	6.9
U86-37	Inc. C37, 86443	75.4	11060	35.38	15.6	0.0	0.0	134	8.0	83.3	3.3
R279Y	RZM-BYV-ER R079	49.2	8118	26.75	15.2	0.0	0.6	133	6.1	82.7	5.6
R228	RZM 1202-#(C)	60.2	9525	31.30	15.2	0.0	0.6	139	8.1	81.4	3.8
R230	RZM R130	59.2	10668	36.27	14.7	2.5	0.0	140	5.5	81.0	5.7
R232	RZM 1201-#(C)	58.4	9378	33.11	14.2	12.4	0.0	133	6.9	80.1	4.8
P201	PMR 1211,...,1216	60.8	9383	30.60	15.4	6.1	0.0	132	6.2	81.5	4.6
P202	PMR 1217,...,1224	49.3	8428	28.26	14.9	10.4	0.0	132	6.4	80.4	4.5
U86-46/2	Inc. C46/2, 86342	51.0	9394	30.60	15.4	0.0	0.0	133	5.8	81.5	4.9
R278	RZM R078	51.4	9819	32.91	14.9	0.0	0.0	138	5.7	81.5	5.3
R278Y	RZM-BYV-ER R078	51.5	9822	31.75	15.5	0.0	0.0	134	6.3	82.0	5.8
US H11	L113401	51.1	9401	32.19	14.6	0.0	0.0	135	8.3	81.3	5.4
Mean			9258.6	31.01	14.9	2.6	0.1	134.9	6.8	81.2	5.1
LSD (.05)			1087.1	3.41	0.6	2.9	0.8	10.1	0.8	1.8	0.8
C.V. (%)			10.2	9.49	3.3	97.1	499.0	6.5	9.8	1.9	13.1
F value			11.1**	9.22**	11.5**	18.9**	0.8NS	0.6NS	17.2**	4.6**	12.9**

[1]Test was uniformly inoculated with beet yellows virus (BYV) and beet western yellows virus (BWYV).

TEST 1493. VIRUS YELLOWS EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993

(cont.)

Variety[5]	Description	Acre Yield Relative[2] %	Sugar Lbs	Beets Tons	Sucrose %	Bolting %	Root Rot %	Beets/ 100' No.	Powdery Mildew[3] Mean	RJAP %	Virus Yellows[4] Mean
Set 1 (1493-1) MM,O.P. Lines (cont.)											

[2]Relative gross sugar yield between entries in BYV/BWYV inoculated test 1493 and corresponding noninoculated entries in test 893. These tests were planted and harvested at different times. Individual ranking within tests is subject to experimental error. Thus, in addition to the effects of virus yellows, there would be differences due to cultural practices and random error. In a broad sense, relative gross sugar yield should give a fair estimate of the differences in resistance/tolerance to virus yellows. As with all field data, estimates of response to virus yellows infection will be improved by comparisons across tests and over years. Relative yield = 100(inoculated mean/noninoculated mean).

[3]Powdery mildew scored from 0 to 9 where 9 = 90-100% of mature leaf area covered by mildew.

[4]Virus yellows scored from 0 to 9 where 9 = 90-100% of the mature leaf area yellow.

[5]268 = Increase of obsolete O.P. variety US75 grown in the 1950's. C37 = YR (yellows resistant), ER (Erwinia resistant) selection from US75. R279Y = C37Rz. R228 = C37 with rhizomania resistance from PI206407. P201 & P202 = C37 x (SB x WB97, WB242). R278 = C46/2Rz. US H11 = (C562CMS x C546) x C36.

TEST 1493. VIRUS YELLOWS EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993
48 entries x 6 replications, RCB; 1-row plots, 20 ft. long. ANOVA to compare means across sets.

Mean	10476.7	33.94	15.4	0.7	0.4	134.2	5.8	82.1	4.8
LSD (.05)	1225.8	3.83	0.5	1.4	1.3	12.1	0.9	1.6	0.8
C.V. (%)	10.3	9.93	2.9	189.0	307.8	7.9	13.5	1.8	14.5
F value	11.5**	9.78**	14.3**	23.8**	1.5*	1.4NS	16.2**	4.2**	12.6**

TEST 1493. VIRUS YELLOWS EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993

(cont.)

Variety[5]	Description	Acre Yield Relative[2] %	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolting %	Root Rot %	Beets/ 100' No.	Powdery Mildew[3] Mean	RJAP %	Virus Yellows[4] Mean
Set 2 (1493-2) MM,O.P. Lines											
Rhizoguard	L893301	53.5	9973	32.98	15.1	0.0	1.9	131	7.3	82.1	5.8
R280	RZM R080	58.5	10744	34.73	15.5	0.0	0.6	140	6.1	82.8	5.3
R280Y	RZM-BYV-ER R080	54.2	10821	34.66	15.6	0.0	0.0	133	6.1	82.1	4.8
R280- 1	Inc. R080- 1	52.5	9937	30.31	16.4	0.0	0.0	136	5.8	82.7	4.4
R280-13	Inc. R080-13	49.0	9568	31.65	15.2	0.0	0.0	136	4.4	80.9	4.8
R280-28	Inc. R080-28	57.8	10698	32.42	16.5	0.0	0.0	133	4.8	82.5	4.4
R280-35	Inc. R080-35	65.0	11983	36.50	16.4	0.0	0.6	136	4.8	82.6	3.3
R280-45	Inc. R080-45	56.5	11181	34.80	16.1	0.0	0.0	133	4.3	81.5	4.0
R280-56	Inc. R080-56	56.1	10642	33.87	15.7	0.0	0.7	128	3.6	81.9	4.6
R280-79	Inc. R080-79	53.0	9760	30.49	16.1	0.0	0.0	123	4.3	82.9	5.3
R280-80	Inc. R080-80	53.4	10355	32.56	15.9	0.0	0.0	134	4.5	82.0	5.0
R122Y2	BYR R922Y	58.7	10814	35.13	15.4	0.0	1.2	132	6.3	81.4	3.8
Mean			10539.6	33.34	15.8	---	0.4	132.8	5.2	82.1	4.6
LSD (.05)			1281.9	4.01	0.5	---	1.3	10.5	0.9	1.5	0.8
C.V. (%)			10.5	10.40	2.7	---	278.2	6.9	14.4	1.6	14.9
F value			2.2*	1.86NS	7.6**	---	1.7NS	1.5NS	12.8**	1.4NS	6.3**

[5]R280 = C54Rz. R280-#'s = half-sib families selected on basis of per se performance when tested under nondiseased, virus yellows, and rhizomania conditions in 1991. R122Y2 = cycle 2 selection for virus yellows resistance from F_3(Y54 x B.maritima).

TEST 1493. VIRUS YELLOWS EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993

(cont.)

Variety[5]	Description	Acre Yield Relative[2] %	Sugar Lbs	Beets Tons	Sucrose %	Bolting %	Root Rot %	Beets/ 100' No.	Powdery Mildew[3] Mean	RJAP %	Virus Yellows[4] Mean
Set 3 (1493-3) MM,O.P. Lines											
6770	high % S check	42.1	8294	24.69	16.8	0.0	0.6	143	7.8	83.3	7.3
R270Y	RZM-BYV-ER R070	59.5	11217	37.23	15.1	0.0	0.0	135	5.2	81.2	4.6
F86-31/6	Inc. C31/6, L86263	67.7	12336	38.16	16.1	0.0	0.0	138	5.3	82.8	3.7
R276	RZM R076	62.3	11525	38.79	14.9	0.0	0.6	131	5.6	81.4	3.7
R276Y	RZM-BYV-ER R076	60.4	11506	38.10	15.1	0.0	0.0	136	5.3	82.3	4.2
Y231-43	Inc.Y131-43(C31-43)	60.4	12735	39.49	16.1	0.0	0.0	140	5.3	83.2	4.3
R276-43	RZM R176-43	56.3	11994	39.07	15.4	0.0	0.0	148	5.4	82.9	5.0
R276-89	RZM R176-89	66.9	12620	41.45	15.2	0.0	0.0	146	5.3	83.2	4.3
Y231-89	Inc.Y131-89(C31-89)	69.4	12989	40.74	15.9	0.0	0.6	134	5.8	82.6	2.5
R282	Inc. R176-43,-89	64.0	12513	40.59	15.4	0.0	1.3	138	5.3	84.3	4.5
R283	rr(C) x R(C)	57.8	11514	37.83	15.2	0.0	0.0	128	4.8	82.7	5.0
Y141	BYR Y841	64.8	11967	36.62	16.3	0.0	0.0	134	3.8	81.9	4.4
Mean			11767.5	37.73	15.6	---	0.3	137.6	5.4	82.7	4.4
LSD (.05)			1315.5	4.03	0.5	---	1.1	11.2	1.0	1.7	0.8
C.V. (%)			9.7	9.23	2.6	---	359.3	7.0	16.3	1.8	15.7
F value			7.0**	9.41**	12.8**	---	1.3NS	2.2*	6.3**	2.1*	15.9**

[5]6770 = high % S check (Beta) grown in Red River Valley. R270Y = Rz composite of O.P. lines. R276,R276Y = C31/6Rz. R276-43 is Rz version of C31-43; C76-43 is a reselection from this line. R276-89 is Rz version of C31-89; C76-89 is a reselection from this line. R282 = composite cross of R76-43 and R76-89 lines. R283 = composite cross between O.P. lines selected for virus yellows resistance and O.P. lines selected for rhizomania resistance. Y141 = VY reselection of C91.

TEST 1493. VIRUS YELLOWS EVALUATION OF MULTIGERM GERMPLASM, SALINAS, CA., 1993

(cont.)

Variety[5]	Description	Acre Yield Relative[2] %	Sugar Lbs	Beets Tons	Sucrose %	Bolting %	Root Rot %	Beets/ 100' No.	Powdery Mildew[3] Mean	RJAP %	Virus Yellows[4] Mean
Set 4 (1493-4)											
Rhizosen	L493304	49.4	9409	32.07	14.7	0.0	0.6	136	7.3	84.6	6.8
Y439	CO, Inc. Y339	67.1	11382	35.36	16.1	0.0	0.6	133	5.3	84.0	4.8
R239C8	C8, RZM R139C7	58.1	11478	39.39	14.5	0.0	2.0	138	4.2	80.2	3.7
Y139	YR, BYR Y939	69.3	12373	37.13	16.7	0.0	0.0	131	3.8	83.2	4.3
Y547	CO, YR-ER-PMR Y347	59.6	10998	34.41	16.0	0.0	0.0	128	5.0	83.4	4.3
R247C8	C8, RZM R147C7	47.5	9449	31.50	15.0	0.0	1.2	136	6.9	82.6	4.9
Y147	YR, BYR Y947	59.4	11696	36.67	15.9	0.0	0.0	124	5.0	82.3	5.2
R207	RZM R107	44.3	7859	26.47	14.9	0.0	0.6	129	8.5	80.2	6.8
R208	RZM R108	41.6	7883	27.38	14.4	0.0	0.6	134	7.3	80.5	6.4
2915	RZM1915-#,1913-#aaxA	57.0	10923	35.50	15.4	0.0	0.0	127	5.3	81.9	3.8
2916	1905aa x 1913,1915		11706	38.16	15.3	0.0	0.0	137	5.4	82.7	3.6
2890	0790mmaax1890,RZM1890		8937	29.97	14.9	0.0	2.0	126	7.3	81.2	5.2
Mean			10341.1	33.67	15.3	---	0.6	131.4	5.9	82.2	5.0
LSD (.05)			1205.3	3.83	0.5	---	1.7	10.5	1.0	1.7	0.8
C.V. (%)			10.1	9.83	3.0	---	224.8	6.9	13.9	1.8	13.1
F value			13.5**	9.62**	15.0	---	1.6NS	1.6NS	18.9**	5.8**	18.8**

[5]Y439 = 1984 seed lot of Y39 and source of selections for virus yellows and rhizomania. R239C8 = cycle 8 from Y39 for resistance to rhizomania based upon root symptoms in 4 mo. old roots. Y139 = continued VY resistant selection from Y39 based upon individual plant performance under severe virus yellows conditions. Y547 = 1985 seed lot of Y47 and source of selections for virus yellows and rhizomania resistance. R247C8 = cycle 8 for resistance to rhizomania. Y147 = continued reselection for VYR. Y207 & Y208 = lines with 50% cercospora leaf spot resistant germplasm from Italy. 2915 = self-fertile, MM, A:aa, Rz population.

TEST 1593. VIRUS YELLOWS EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1993

24 entries x 8 replications, RCB (equalized)
1-row plots, 20 ft. long
3 sets each with 8 entries x 8 reps, Latin Square

Planted: March 9, 1993
Harvested: October 21, 1993
BYV/BWYV Inoc: May 6, 1993[1]

Variety[5]	Description	Acre Yield Relative[2] %	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Mean Yellows Rating[4]	PM Mean[3]	RJAP %
(Set 1: 1593-1)										
Experimental Hybrids										
R278H39	89-762-17CMS x R078	53.6	10293	35.60	14.4	0.9	129	5.8	5.5	82.2
R280H22	0722HO x R080	66.4	11260	36.80	15.3	0.5	134	5.8	6.5	82.4
R080H29	C790-6aa x R980	62.6	10917	36.89	14.8	1.2	120	5.0	4.8	81.9
R280H33	C790-54aa x R080	65.1	11365	38.22	14.8	0.5	106	4.4	4.8	82.9
R280H90	C790aa x R080	56.5	10698	35.88	14.9	0.0	124	5.2	5.8	82.8
R280H92	F85-796-22HO x R080	59.1	9825	33.04	14.9	1.1	111	5.3	6.5	81.8
R280H97	C796-43HO x R080	54.9	9532	32.73	14.6	0.5	125	5.8	6.8	82.3
R280H39	89-762-17CMS x R080	57.0	10212	35.37	14.5	0.0	116	6.0	5.9	83.6
Mean			10512.8	35.57	14.8	0.6	120.6	5.4	5.8	82.5
LSD (.05)			987.7	3.50	0.5	1.8	12.5	0.4	0.7	2.2
C.V. (%)			9.3	9.74	3.7	298.7	10.2	8.0	12.8	2.6
F value			3.6**	2.37*	2.4*	0.6NS	4.8**	11.8**	8.7**	0.6NS
(Set 2: 1593-2)										
790-68H26 x Pollinator										
Rhizoguard	L893301	56.0	8879	30.95	14.4	0.0	134	6.1	6.2	83.2
6770	high %S check (Beta)	44.7	7801	24.03	16.2	0.9	130	7.2	6.6	83.9
R280H18	88-790-68H26 x R080	53.7	10357	34.59	14.9	1.4	130	5.7	6.8	83.9
R276H18	88-790-68H26 x R076	57.2	10414	33.97	15.4	0.5	128	4.9	6.6	83.5
R278H18	88-790-68H26 x R078	59.0	10826	35.33	15.3	0.0	126	5.2	7.0	82.7
R282H18	88-790-68H26 x R176-43,-89	60.0	11665	37.97	15.4	2.9	125	4.6	5.5	82.8
2915H18	88-790-68H26 x 1915	56.1	10201	34.49	14.8	0.0	128	5.1	6.3	82.5
N203H18	88-790-68H26 x N103,N103-1	53.7	7771	31.80	12.3	27.8	106	6.7	8.9	79.8
Mean			9739.2	32.89	14.8	4.2	125.9	5.7	6.7	82.8
LSD (.05)			1217.0	3.33	1.1	4.9	10.9	0.4	0.9	2.3
C.V. (%)			12.4	10.02	7.2	115.3	8.6	7.8	13.4	2.7
F value			11.2**	12.82**	9.5**	31.5**	5.2**	33.7**	9.4**	2.8*

TEST 1593. VIRUS YELLOWS EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1993
(cont.)

Variety[5]	Description	Acre Yield Relative[2] %	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Mean Yellows Rating[4]	PM Mean[3]	RJAP %
(Set 3: 1593-3)										
309H3 x progenies from popn-911,-913,-915										
2915H20	87-309H3 x 1913,1915	57.3	9939	33.34	14.9	0.4	136	5.5	7.3	82.1
2911-4H20	87-309H3 x RZM C911-4	59.4	10864	34.23	15.9	0.5	134	5.5	7.3	81.5
2911-12H20	87-309H3 x RZM C911-12	51.0	10258	33.43	15.4	0.0	127	5.8	7.8	82.0
2911-24H20	87-309H3 x 0911-24	51.9	9148	30.01	15.3	0.5	136	5.6	7.4	82.8
2913- 9H20	87-309H3 x 0913-9	61.4	11332	36.69	15.5	0.0	127	5.2	6.8	81.2
2915- 4H20	87-309H3 x 0915-4	54.5	9952	33.10	15.1	0.9	133	5.6	7.3	81.7
2915- 7H20	87-309H3 x 0915-7	54.2	10928	35.33	15.4	0.0	133	5.0	7.3	81.7
2915-46H20	87-309H3 x 0915-46	48.3	9408	30.74	15.3	0.0	133	5.2	7.2	81.2
Mean			10228.6	33.36	15.3	0.3	132.2	5.4	7.3	81.7
LSD (.05)			930.2	2.77	0.5	1.0	6.6	0.4	0.8	1.5
C.V. (%)			9.0	1.37	3.0	353.1	4.9	7.7	10.8	1.9
F value			5.5**	5.14**	3.0*	0.9NS	2.4*	3.0*	0.9NS	1.0NS

TEST 1593. VIRUS YELLOWS EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1993
24 entries x 8 replications, RCB (equalized), 1-row plots, 20 ft.long

Mean	10160.2	33.94	15.0	1.7	126.2	5.5	6.6	82.3
LSD (.05)	1048.5	3.26	0.7	3.1	10.8	0.4	0.8	2.0
C.V. (%)	10.4	9.71	6.7	186.4	8.6	7.9	12.3	2.5
F value	7.4**	6.83**	4.9**	25.2**	5.2**	15.9**	10.8**	1.8*

[1]Test was uniformly inoculated with BYV/BWYV.
[2]Relative gross sugar yield between entries in BYV/BWYV inoculated test 1593 and corresponding entries in Tests 993, 1193, & 1293: Test 1593-1 corresponds to Test 1293; Test 1593-2 corresponds to Test 1193; Test 1593-3 corresponds to Test 993-1. (See footnote 2 for Test 1493).
[3]Powdery mildew scored from 0 to 9 where 9 = 90-100% of mature leaf area covered by mildew.
[4]Virus yellows scored from 0 to 9 where 9 = 90-100% of the mature leaf area yellow.
[5]790-68H26 = C309CMS x C790-68. 309H3 = C562CMS x C309. R076, R078 & R080 are near-isogenic Rz lines of C31/6, C46/2, & C54. R176-43,-89 is unselected version of C76-43,-89. N103, N103-1 are nematode resistant C306, C306-1. 1913, 1915 is similar to C918.

TEST 1693. VIRUS YELLOWS EVALUATION OF SELECTED PROGENIES, SALINAS, CA., 1993

24 entries x 8 replications, RCB (equalized)
1-row plots, 20 ft. long
3 sets each with 8 entries x 8 reps, Latin Square

Planted: March 9, 1993
Harvested: October 18, 1993
BYV/BWYV Inoc: May 6, 1993[1]

Variety[5]	Description	Acre Yield Relative[2] %	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Mean Yellows Rating[4]	PM Mean[3]	RJAP %
Test 1693-1: Checks and topcrosses										
6770	High % sugar check	45.9	8759	27.62	15.8	0.4	139	7.2	7.1	82.3
Rhizoguard	L893301	52.3	9315	33.08	14.1	0.5	134	6.3	7.5	83.5
R280H20	87-309H3 x R080	55.8	10230	34.08	15.0	0.0	143	5.5	7.5	81.3
R276H20	87-309H3 x R076	59.0	10515	35.44	14.8	0.0	141	5.1	7.4	82.2
R278H20	87-309H3 x R078	55.0	9659	32.63	14.8	0.0	134	6.0	7.4	81.8
R282H20	87-309H3 x R176-43,-89	60.9	11320	36.82	15.4	0.5	133	5.2	7.4	83.7
N203H20	87-309H3 x N103,N103-1	47.7	7028	30.74	11.4	15.6	139	6.8	8.6	80.1
R282H89	88-790-68CMS x R176-43,-89	n/a	11451	38.83	14.8	2.3	113	4.6	5.9	83.2
Mean			9784.9	33.65	14.5	2.4	134.7	5.8	7.3	82.3
LSD (.05)			959.3	2.95	0.6	3.9	10.8	0.5	0.5	2.2
C.V. (%)			9.7	8.70	3.9	160.7	8.0	8.9	7.3	2.6
F value			18.7**	11.54**	46.9**	15.4**	6.1**	23.2**	15.4**	2.5*
Test 1693-2: Progenies from R80										
R280- 1H20	87-309H3 x R080- 1	53.6	10083	33.23	15.2	0.0	141	5.5	7.9	82.0
R280-13H20	87-309H3 x R080-13	53.8	10055	34.70	14.5	0.0	139	5.4	7.0	81.7
R280-28H20	87-309H3 x R080-28	53.3	10024	32.96	15.2	0.4	131	5.8	7.2	82.5
R280-35H20	87-309H3 x R080-35	57.8	10771	34.97	15.4	0.0	132	5.4	7.4	81.6
R280-45H20	87-309H3 x R080-45	57.0	10692	35.28	15.2	0.0	139	5.3	6.9	80.4
R280-56H20	87-309H3 x R080-56	58.7	10298	34.36	15.0	1.6	131	5.5	6.8	81.4
R280-79H20	87-309H3 x R080-79	49.2	9282	30.92	15.0	0.0	136	5.7	7.3	80.8
R280-80H20	87-309H3 x R080-80	53.4	9787	32.91	14.9	0.0	131	5.3	7.1	80.1
Mean			10124.0	33.67	15.0	0.3	135.1	5.5	7.2	81.3
LSD (.05)			788.5	2.24	0.4	1.0	9.4	0.5	0.5	1.5
C.V. (%)			7.7	6.59	2.5	367.6	6.9	8.2	7.1	1.8
F value			3.0*	3.40**	4.3**	2.9*	1.8NS	1.2NS	3.6**	2.6*

TEST 1693. VIRUS YELLOWS EVALUATION OF SELECTED PROGENIES, SALINAS, CA., 1993
(cont.)

Variety[5]	Description	Acre Yield Relative[2] %	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Mean Yellows Rating[4]	PM Mean[3]	RJAP %
Test 1693-3: Progenies from popn-911,-913,-915 & popn-864										
2915H20	87-309H3 x 1913,1915	53.7	9746	33.33	14.6	0.0	134	5.9	7.7	80.7
2911-4H20	87-309H3 x RZM 1911-4	57.2	10444	33.93	15.4	0.0	131	5.6	7.2	81.1
2911-12H20	87-309H3 x RZM 1911-12	51.8	10410	34.95	14.9	0.0	134	6.0	8.1	81.8
2913-9H20	87-309H3 x 0913-9	58.7	10844	36.40	14.9	0.0	131	4.9	7.1	81.8
2915-4H20	87-309H3 x 0915-4	56.3	10284	34.72	14.8	0.0	143	5.6	7.5	81.4
R280H68	1867Raa x R080	53.5	10031	34.70	14.5	0.5	126	6.3	7.0	82.3
R280H62-1	0864-1aa x R080	57.2	10372	35.88	14.4	0.0	121	5.7	6.6	82.0
R280H62-28	0864-28aa x R080	59.0	10635	36.07	14.8	0.0	99	5.8	7.2	82.2
Mean			10345.8	35.00	14.8	0.1	127.5	5.7	8.3	81.7
LSD (.05)			879.3	2.54	0.6	0.5	12.7	0.4	0.7	1.7
C.V. (%)			8.4	7.18	3.8	800.0	9.9	7.7	9.6	2.1
F value			1.2NS	1.44NS	2.4*	1.0NS	8.5**	7.2**	3.3**	0.9NS

TEST 1693. VIRUS YELLOWS EVALUATION OF SELECTED PROGENIES, SALINAS, CA., 1993
24 entries x 8 replications, RCB (equalized), 1-row plots, 20 ft. long. To compare means across sets.

Mean	10084.9	34.11	14.8	0.9	132.4	5.7	7.3	81.7
LSD (.05)	860.9	2.58	0.5	2.3	12.1	0.5	0.6	1.7
C.V. (%)	8.6	7.63	3.7	259.7	9.3	8.6	8.5	2.1
F value	8.5**	6.09**	17.8**	14.4**	5.2**	10.7**	5.6**	2.4**

[1]Test was uniformly inoculated with BYV/BWYV.
[2]Relative gross sugar yield between entries in BYV/BWYV inoculated test 1693 and corresponding non-inoculated entries in test 1093. See footnote 2 for Test 1493.
[3]Powdery mildew scored from 0 to 9 where 9 = 90-100% of mature leaf area covered by mildew.
[4]Virus yellows scored from 0 to 9 where 9 = 90-100% of the mature leaf area yellow.
[5]309H3 = C562CMS x C309. 1867 = S^f,A:aa,mm,Rz population. 0864-1 and 0864-28 = progeny lines selected from popn-864. R076,R078,R080 = near-isogenic Rz lines of C31/6, C46/2, and C54. R080-# = progeny lines selected from line R80. N103,N103-1 = cyst nematode resistant C603,C603-1. R176-43,-89 are similar to C76-43,-89. 1913,1915 are similar to C918. 1911-4 = C911-4. 1911-12 = C911-12. 0913-9 = progeny family from popn-913. 0915-4 from popn-915.

TEST 1793. VIRUS YELLOWS EVALUATION OF TOPCROSS HYBRIDS FROM POPN-911,-913, & -915, SALINAS, CA., 1993

32 entries x 6 replications, RCB
1-row plots, 20 ft. long

Planted: March 9, 1993
Inoc. BYV/BWYV: May 6, 1993
Harvested: September 30, 1993

Variety	Description[1]	Acre Yield Relative[2]	Acre Yield Sugar	Acre Yield Beets	Sucrose	Root Rot	Beets/ 100'	Mean Yellows	PM	RJAP
		%	Lbs	Tons	%	%	No.	Mean	Rating	%
Checks										
R282H26	87-309CMS x R176-43,-89	---	10411	33.80	15.4	0.7	137	5.3	7.0	84.0
2915H26	87-309CMS x 1913,1915	---	10241	35.01	14.6	0.0	139	5.5	7.0	80.5
2865H15	1915aa x 1865,1865-#	49.3	9705	33.89	14.3	0.0	139	5.8	6.0	81.8
2915H65	1865aa x 1913,1915	46.6	9324	32.28	14.4	0.0	134	5.7	6.0	82.3
2915H65	1865aa x 1913,1915	48.1	9290	32.98	14.1	0.0	143	5.9	7.0	79.4
Rhizoguard	L893301	57.6	9058	31.93	14.2	1.5	128	5.9	7.0	82.8
2865H13	1913aa x 1865,1865-#	46.2	8870	31.36	14.1	0.0	140	5.8	7.0	81.0
6770	High % sugar check	44.1	8360	27.51	15.2	0.6	138	6.9	5.0	85.3
MM Progenies x mm Tester										
2865H47-9	0913- 9aa x 1865,1865-#	53.6	10242	35.71	14.4	0.0	148	4.5	7.0	81.8
2865H43-12	1911-12aa x " "	52.4	10225	34.73	14.8	0.0	128	5.4	6.0	81.9
2865H45-18	1913-18aa x " "	53.9	10190	34.80	14.7	0.0	137	5.3	6.0	81.7
2865H48-6	0915- 6aa x " "	55.4	10185	34.45	14.8	0.0	138	4.9	6.0	83.8
2865H45-25	1913-25aa x 1865,1865-#	54.4	9998	34.36	14.6	0.0	136	5.1	5.0	82.0
2865H48-24	0915-24aa x " "	53.1	9982	34.23	14.6	0.0	138	5.1	6.0	81.1
2865H48-7	0915- 7aa x " "	55.0	9804	33.61	14.6	0.0	137	5.7	7.0	81.4
2865H45-22	1913-22aa x " "	51.7	9736	34.07	14.4	0.0	143	5.3	5.0	80.5
2865H48-4	0915- 4aa x 1865,1865-#	57.2	9723	34.03	14.3	0.0	137	5.4	6.0	80.1
2865H46-1	0911- 1aa x " "	49.0	9696	34.17	14.2	0.0	141	5.7	6.0	79.7
2865H48-1	0915- 1aa x " "	55.8	9677	33.44	14.5	0.0	135	5.4	6.0	82.5
2865H48-23	0915-23aa x " "	52.3	9676	33.05	14.6	0.0	145	5.6	6.0	81.7

TEST 1793. VIRUS YELLOWS EVALUATION OF TOPCROSS HYBRIDS FROM POPN-911,-913, & -915, SALINAS, CA., 1993
(cont.)

Variety	Description[1]	Acre Yield Relative[2]	Sugar	Beets	Sucrose	Root Rot	Beets/ 100'	Mean Yellows	PM	RJAP
		%	Lbs	Tons	%	%	No.	Mean	Rating	%
MM Progenies x mm Tester (cont.)										
2865H43-50	1911-50aa x 1865,1865-#	55.7	9597	32.63	14.7	0.0	141	5.4	6.0	83.2
2865H47-6	0913-6aa x " "	52.2	9471	32.46	14.6	0.0	133	5.3	6.0	80.5
2865H48-34	0915-34aa x " "	49.6	9429	32.77	14.4	0.0	140	5.9	6.0	81.6
2865H48-27	0915-27aa x " "	48.8	9399	32.77	14.4	0.0	140	5.3	5.0	81.4
2865H45-5	1913- 5aa x 1865,1865-#	49.4	9315	32.21	14.5	0.0	135	5.3	6.0	81.6
2865H48-22	0915-22aa x " "	52.8	9216	31.44	14.6	0.0	138	5.6	6.0	82.2
2865H46-4B	0911-4(B) x " "	52.1	9124	31.16	14.7	0.0	138	5.8	6.0	81.7
2865H48-16	0915-16aa x " "	48.2	9062	32.56	13.9	0.0	140	5.8	6.0	80.3
2865H43-14	1911-14aa x 1865,1865-#	47.3	8984	30.81	14.6	0.7	134	5.6	6.0	80.5
2865H46-24	0911-24aa x " "	48.7	8909	31.30	14.3	0.0	142	5.4	8.0	81.6
2865H48-46	0915-46aa x " "	46.8	8797	30.84	14.3	0.0	137	5.8	5.0	80.3
2865H43-4	1911- 4aa x " "	53.2	8786	31.07	14.1	0.0	123	6.0	5.0	80.8
Mean			9515.2	32.86	14.5	0.1	137.5	5.5	6.0	81.6
LSD (.05)			1165.5	4.02	0.5	0.7	11.8	0.5	1.2	2.1
C.V. (%)			10.7	10.72	3.1	586.5	7.5	8.5	17.9	2.2
F value			1.5**	1.34NS	2.9**	1.5NS	1.4NS	4.6**	2.7**	3.0**

Notes: Test was uniformly inoculated with virus yellows (BYV/BWYV) on May 6, 1993. Yellows were uniform and severe. Powdery mildew was scored 9/15/93 after the efficacy of Bayleton ceased. Yellows symptoms (9 = severe yellowing) were scored 8/25 and 9/03/93. See test 993 for the same entries under non-virus yellows inoculated conditions.

[1]1865,1865-# tester is a monogerm population similar to C309/C310, but segregates for resistance to rhizomania. 1913,1915 is a multigerm, self-fertile, A:aa population that segregates for resistance to rhizomania. The progeny lines are extractions from popns-911,-913,-915. R176-43; -89 is unselected version of C76-43; -89. 1911-4, -12, -14, -50 are unselected versions of C911-4, C911-12, C911-14, & C911-50.

[2]Relative gross sugar yield between entries in BYV/BWYV inoculated Test 1793 and corresponding noninoculated entries in Test 993. See footnote 2 of Test 1493.

DAVIS 1993-1. EVALUATION OF HYBRIDS FOR REACTION TO VIRUS YELLOWS, DAVIS, CA., 1993

12 entries x 2 virus trtmts x 6 reps (Split-plot)
1-row plots, 28 ft. long

Planted: May 28, 1993
Harvested: November 3, 1993
BYV/BWYV Inoc.: July 9, 1993

Variety	Description	Acre Yield[1] Sugar lbs	Acre Yield[1] Beets tons	Sucrose[1] %	Acre Yield[2] Sugar lbs	Acre Yield[2] Beets tons	Sucrose[2] %	Acre Yield[3] Sugar lbs	Acre Yield[3] Beets tons	Sucrose[3] %
Commercial checks										
SS-VY1	Spreckels L921068	5005	17.51	14.2	3935	14.12	14.0	6076	20.90	14.5
4454	Betaseed	5822	20.04	14.5	4613	16.39	14.1	7031	23.69	14.9
HH 66	Holly	4967	18.23	13.6	3983	14.63	13.6	5952	21.84	13.6
6027	Hilleshog-MH	5464	19.21	14.2	4493	15.97	14.0	6434	22.46	14.3
USDA Experimental Hybrids										
R276H18	(C309 x C790-68) x R076	5254	19.15	13.7	4218	15.74	13.5	6291	22.56	13.9
R278H18	(C309 x C790-68) x R078	5492	19.37	14.2	4592	16.41	14.0	6391	22.34	14.3
R282H18	(C309 x C790-68) x R176-43,-89	5709	20.19	14.1	4808	17.36	13.9	6611	23.02	14.4
2915H18	(C309 x C790-68) x 1915	5198	18.84	13.7	4263	15.78	13.5	6133	21.90	14.0
R280H18	(C309 x C790-68) x R080	5460	19.04	14.3	4604	16.21	14.2	6316	21.87	14.4
R280H33	C790-54aa x R080	5455	19.38	14.0	4375	15.95	13.7	6535	22.82	14.3
R280H97	C796-43aa x R080	4962	17.71	13.9	3795	13.95	13.7	6129	21.48	14.2
Susceptible check										
6770	High % S, susc. check	5242	16.50	15.7	3741	12.48	15.0	6743	20.53	16.4
Mean		5336.0	18.77	14.2	4285.2	15.41	13.9	6386.8	22.12	14.4
LSD (.05)		411.6	1.44	0.3	582.0	2.04	0.5	582.0	2.04	0.5
C.V. (%)		9.5	9.48	2.9	9.5	9.48	2.9	9.5	9.48	2.9
F value		3.6**	4.45**	21.8**	6.6*	5.70*	12.8*	6.6*	5.70*	12.8*
F value - virus		*	*	*						
F value - var x virus		NS	NS	*						

[1]Variety means over both virus treatments analyzed as split-plot.
[2]Variety means for inoculated treatment.
[3]Variety means for noninoculated treatment.

DAVIS 1993-1. EVALUATION OF HYBRIDS FOR REACTION TO VIRUS YELLOWS, DAVIS, CA., 1993
(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
Commercial checks								
SS-VY1	4333	247	86.6	672.2	431	2123	615	12660
4454	5032	250	86.6	790.1	376	2329	611	12939
HH 66	4263	234	86.0	704.4	476	2107	613	12760
6027	4668	243	85.6	795.9	431	2428	633	13589
USDA Experimental Hybrids								
R276H18	4515	236	85.9	739.9	415	2313	593	12869
R278H18	4760	246	86.7	731.6	361	2113	633	12558
R282H18	4916	243	86.2	793.3	414	2142	655	13025
2915H18	4443	235	85.6	754.8	349	2196	680	13173
R280H18	4704	246	86.2	756.3	421	2207	649	13158
R280H33	4721	243	86.6	734.5	407	2190	591	12514
R280H97	4245	238	85.5	716.9	395	2531	604	13448
Susceptible check								
6770	4650	279	88.4	592.7	435	2108	555	12062
Mean	4604.1	245.0	86.3	731.9	409.2	2232.4	619.3	12896.4
LSD (.05)	355.9	7.0	0.8	73.8	75.3	241.4	55.1	675.8
C.V. (%)	9.6	3.5	1.1	12.5	22.7	13.4	11.0	6.5
F value - var	3.9**	22.0**	8.0**	4.8**	1.7NS	2.6**	2.9**	3.1**
Non-inoc Mean	5527.8	250.1	86.5	859.0	421.6	2169.5	634.9	12930.4
Inoc. Mean	3680.4	240.0	86.1	604.8	396.8	2295.3	603.7	12862.3
Virus	*	*	NS	NS	NS	*	NS	NS
Var x virus	*	*	NS	NS	*	*	NS	NS

Note: Variety means over both virus treatments analyzed as split-plot (12 var x 12 reps). Recoverable sugar, sodium, potassium, and NH_2-N values should be considered estimates as there were many missing plots. Tests were planted late due to wet field conditions. Grown by Dr. S. Kaffka and G. Peterson, U.C. Davis. Sugar and impurity analyses by Spreckels Sugar, Woodland.

DAVIS 1993-2. EVALUATION OF SELECTED PROGENY LINES FOR PERFORMANCE UNDER VY CONDITIONS, DAVIS, CA., 1993

12 entries x 6 replications, RCB (equalized)
1-row plots, 28 ft. long

Planted: May 28, 1993
Harvested: November 3, 1993
BYV/BWYV Inoc.: July 9, 1993

Variety	Description	Acre Yield Sugar lbs	Acre Yield Beets tons	Sucrose %	Clean Beets %
6770	High % S, susc. check	3554	11.77	15.1	93.4
R276Y	RZM-VY-ER R076	4339	16.70	13.0	93.5
R270Y	RZM-VY-ER R070	4769	17.84	13.4	93.9
R280Y	RZM-VY-ER R080	4576	16.86	13.6	95.4
R280- 1	Inc. R080- 1	4303	15.12	14.2	93.6
R280-13	Inc. R080-13	4027	14.53	13.9	94.2
R280-28	Inc. R080-28	4079	14.01	14.6	92.1
R280-35	Inc. R080-35	4185	14.80	14.2	90.6
R280-45	Inc. R080-45	4021	14.24	14.2	92.2
R280-56	Inc. R080-56	3978	14.64	13.6	92.6
R280-79	Inc. R080-79	4003	13.87	14.4	94.2
R280-80	Inc. R080-80	3738	13.85	13.5	93.1
Mean		4131.1	14.85	14.0	93.2
LSD (.05)		460.6	1.62	0.5	0.0
C.V. (%)		9.6	9.40	3.0	2.2
F value		4.3**	8.16**	11.5**	2.5**

Note: See Tests 893, 1093, 1493, 1693 & 2793 at Salinas.
Recoverable sugar, sodium, potassium, and NH_2-N values should be considered estimates as there were many missing plots. Tests were planted late due to wet field conditions. Grown by Dr. S. Kaffka and G. Peterson, U.C. Davis. Sugar and impurity analyses by Spreckels Sugar, Woodland.

DAVIS 1993-2. EVALUATION OF SELECTED PROGENY LINES FOR PERFORMANCE UNDER VY CONDITIONS, DAVIS, CA., 1993

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
6770	3099	264	87.2	455	333	2378	600	12816
R276Y	3643	219	84.0	696	445	2824	546	13804
R270Y	4012	227	84.2	757	418	2843	571	13997
R280Y	3830	228	83.8	747	395	3264	533	14602
R280- 1	3687	243	85.5	616	334	2766	592	13710
R280-13	3438	237	85.3	589	311	2928	548	13613
R280-28	3511	251	86.1	568	329	2918	527	13451
R280-35	3565	242	85.3	620	318	2955	561	13833
R280-45	3453	243	85.9	569	301	2774	562	13329
R280-56	3308	225	82.9	671	433	3122	643	15425
R280-79	3414	246	85.3	589	365	2781	618	14098
R280-80	3167	228	84.5	571	390	2804	574	13823
Mean	3510.5	237.7	85.0	620.6	364.2	2863.3	572.9	13875.1
LSD (.05)	425.7	13.6	2.5	119.0	103.6	624.6	69.4	2039.9
C.V. (%)	10.5	4.9	2.5	16.5	24.5	18.8	10.4	12.7
F value	3.1**	7.3**	1.8NS	4.1**	1.9NS	1.0NS	2.0NS	0.8NS

DAVIS 1993-3. EVALUATION OF TOPCROSS HYBRIDS OF SELECTED PROGENY LINES UNDER VY CONDITIONS, DAVIS, CA., 1993

12 entries x 6 replications, RCB (equalized)
1-row plots, 28 ft. long

Planted: May 28, 1993
Harvested: November 3, 1993
BYV/BWYV Inoc.: July 9, 1993

Variety	Description	Acre Yield Sugar lbs	Acre Yield Beets tons	Sucrose %	Clean Beets %
2865H43- 4	1911- 4aa x 1865	3479	13.97	12.5	92.4
2865H43-12	1911-12aa x 1865	3820	15.06	12.7	92.0
2865H43-14	1911-14aa x 1865	3551	13.74	12.9	92.6
2865H43-50	1911-50aa x 1865	3630	14.02	13.0	89.4
2865H45- 5	1913- 5aa x 1865	3429	13.52	12.7	91.5
2865H45-18	1913-18aa x 1865	4230	15.94	13.3	90.5
2865H45-22	1913-22aa x 1865	3833	15.04	12.8	90.5
2865H45-25	1913-25aa x 1865	3807	15.01	12.7	91.7
2865H46-24	0911-24aa x 1865	3198	12.69	12.6	90.7
2865H47-9	0913-9aa x 1865	3667	14.31	12.8	91.1
2865H48-4	0915-4aa x 1865	3609	14.21	12.7	91.6
2865H48-7	0915-7aa x 1865	3736	14.88	12.6	91.5
Mean		3665.6	14.37	12.8	91.3
LSD (.05)		350.6	1.40	0.5	0.4
C.V. (%)		8.2	8.42	3.1	0.0
F value		4.3**	3.09**	1.7NS	0.0NS

Note: See Tests 793, 993, 1793 & 2993 at Salinas.
Recoverable sugar, sodium, potassium, and NH_2-N values should be considered estimates as there were many missing plots. Tests were planted late due to wet field conditions. Grown by Dr. S. Kaffka and G. Peterson, U.C. Davis. Sugar and impurity analyses by Spreckels Sugar, Woodland.

DAVIS 1993-3. EVALUATION OF TOPCROSS HYBRIDS OF SELECTED PROGENY LINES UNDER VY CONDITIONS, DAVIS, CA., 1993

(cont.)

Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known Sugar/Loss lbs/a	Sodium ppm	Potassium ppm	NH2-N ppm	Impur. Value
2865H43- 4	2846	204	81.8	633	577	2606	691	15105
2865H43-12	3127	208	81.8	693	500	2793	697	15353
2865H43-14	2922	213	82.3	629	536	2564	731	15231
2865H43-50	3072	220	84.6	559	407	2258	650	13248
2865H45- 5	2829	210	82.5	600	593	2572	661	14781
2865H45-18	3529	221	83.4	701	529	2647	653	14671
2865H45-22	3197	213	83.4	636	523	2460	646	14116
2865H45-25	3136	210	82.4	670	483	2880	631	14885
2865H46-24	2647	209	82.7	551	611	2387	676	14528
2865H47-9	3049	213	83.1	618	506	2508	669	14394
2865H48-4	2938	207	81.4	671	593	2852	687	15730
2865H48-7	3071	206	82.2	665	518	2679	677	14940
Mean	3030.2	211.2	82.6	635.5	531.3	2600.3	672.4	14748.5
LSD (.05)	303.7	10.8	1.8	85.5	88.6	522.0	69.3	1348.5
C.V. (%)	8.6	4.4	1.9	11.6	14.4	17.3	8.9	7.9
F value	4.3**	1.9NS	1.9*	2.6**	3.3**	1.0NS	1.2NS	1.9NS

TEST 1393. VIRUS YELLOWS EVALUATION OF Y54 x B.m. GERMPLASM LINES, SALINAS, CA., 1993

12 entries x 8 replications, RCB
1-row plots, 20 ft. long
2 sets with 4 entries and 8 entries in incomplete blocks

Planted: March 9, 1993
Harvested: October 8, 1993
BYV/BWYV Inoc.: May 6, 1993

Variety[1]	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolting %	Root Rot %	Beets/ 100′ No.	Powdery Mildew Score	RJAP %	Virus Yellows Mean
Set 1 (1393-1) Hybrids										
R280H20	U87-309H3 x R080	9877	34.18	14.4	0.0	0.5	140	8.0	81.5	5.8
Y954H20	U87-309H3 x Y854	9841	33.71	14.6	0.0	1.0	141	8.0	80.6	5.4
R222R4H20	87-309H3 x RZM R122R3	9098	33.98	13.4	0.0	0.9	144	9.0	79.6	6.1
Rhizoguard	L893301	8767	31.72	13.8	0.0	1.5	135	7.0	81.8	6.4
Set 2 (1393-2) Lines										
R022Y	Inc. R922Y	10151	35.96	14.1	0.0	0.0	131	6.0	80.1	4.9
R122Y2	BYV R922Y	10080	36.05	14.0	0.0	1.5	130	6.0	80.2	4.3
R280Y (Iso)	RZM-BYV-ER R080	9687	34.81	13.9	0.0	0.0	135	6.0	81.0	5.5
Y954	Inc. Y854	9518	32.08	14.9	0.0	0.0	129	6.0	82.4	5.1
R722	Inc. F_2(Y54 x B.m.)(C50)	9279	34.40	13.5	6.6	1.8	135	6.0	78.5	5.3
R122R3	RZM R022R2	8631	33.86	12.8	0.9	5.0	138	8.0	77.3	5.8
R221	RZM R121 (C48)	8596	31.60	13.6	0.0	0.5	131	7.0	79.8	5.5
R222R4	RZM R122R3	8248	32.72	12.6	2.8	3.3	129	8.0	78.1	6.3
Mean		9314.4	33.76	13.8	0.9	1.3	134.8	7.1	80.1	5.5
LSD (.05)		921.0	3.15	0.5	1.2	2.2	9.6	0.8	1.8	0.6
C.V. (%)		9.9	9.37	3.3	135.7	163.0	7.1	10.9	2.3	10.6
F value		3.9**	1.79NS	17.8**	23.1**	3.9**	2.1*	14.2**	5.7**	8.1**

Notes: See Test 693 for performance under nondiseased conditions and Tests 2793-2 & R593 for performance under rhizomania conditions. Data from these tests suggested that rhizomania resistance selection and virus yellows resistance selection were particular for factors for resistance to rhizomania and virus yellows, respectively.

[1]See footnote 1 for Test 693.

VARIETY TRIALS, BRAWLEY, CALIFORNIA, 1992-93
USDA-ARS. Irrigated Desert Research Station

Tests were located on 104 beds (3 acres) on south side of block J. Rotation previously had not included sugarbeet. All fertilizer was applied pre-plant as 46:0:0 and 11:52:0 for a total of 142 units of N and 125 units of P_2O_5. Rhizomania test B293 was located on 20 beds in block K. For many years a 3-year rotation included sugarbeet trials. Rhizomania was recognized in trials in 1989-90. Beets were not grown in 1990-91, but rhizomania trials were grown in 1991-92 and 1992-93. Rhizomania was severe in 1992-93. For block K, 129 units of N and 149 units of P_2O_5 were applied preplant.

Summary: Arrangement of 1992-93 Tests

Test No.	Entries per Test	No. Reps	Rows per Plot	Plot Length	Harv Date	Test Design	Sugar Samples/ Plot
B193[1]	4	6	1	14 ft	5/20	1	1
B293[2]	12	6	1	14	2	2	2
B393[3]	16	4	1	10	3	3	3
B493	32	8	1	24	5/14	RCB	1
B593	32	8	1	24	5/17	RCB	2
B693	16	8	1	24	5/18	RCB	1
B793	8	8	1	24	5/18	RCB	1
B893	48	8	1	15	5/19	RCB	1
B993	24	8	1	15	5/20	RCB	1

Planted September 24, 1992. Watered 9/28/92 by sprinkler. After emergence, watered by furrow on 10/20/92, 11/13, 2/21, 3/9/93, 3/31, 4/21, & 5/4. Thinned 11/2/92. Poast (0.50 pt/A) for grass control. Thiodan (2 pts/A) and Lorsban (0.75 pts/A) for flea beetle control.

[1]Variety x Date of Planting Effects of Whitefly infestation: Split-plot design with planting (watering) dates of 9/11, 9/28, 10/9 and 10/23/92.

[2]Effects of Variety x Harvest Dates on Rhizomania: Split-plot design with harvest dates on 4/16/93, 5/12/93, and 7/1/93.

[3]Root Rot Test: Split-plot design with 3 disease treatments. Inoculated with Phytophthora, Pythium aphanidermatum and noninoc. control. Not harvested for yield. Scored for root rot 7/1/93. Root rot did not occur. (Test in cooperation with Dr. J. Gerik, Holly Sugar).

Remarks - Nitrogen status was moderately high. Tests were off water only 3 weeks at harvest, so still lush. Powdery mildew not controlled and moderate at harvest. Low incidence of Empoasca but high infestation of mites. No significant problems or incidence of other diseases or pests noted. Field was uniform and test results should be reliable.

Acknowledgements - Clifford Brown, IDRS, for managing these trials. Holly Sugar at Brawley for field plot harvesting equipment and running sugar samples.

TEST B193. EFFECTS OF VARIETY x DATE OF PLANTING ON WHITEFLY INFESTATION, BRAWLEY, CA., 1992-93

4 entries x 6 replications, Split-plot
1-row plots, 18 ft. long (24 blocks)

Planted: 09/10/92, 09/24/92, 10/08/92, 10/22/92
Harvested: May 20, 1993

Treatment	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
Varieties							
(2) HH 41	7474	30.87	12.12	0.0	140	93.8	355
(4) SS-IV1	7294	29.01	12.54	0.2	139	95.1	311
(3) 4823	6885	27.27	12.60	0.7	148	92.1	316
(1) US H11	5414	23.82	11.38	0.0	143	91.7	446
Planting Date							
(1) 09/10/92	7339	29.34	12.46	0.7	125	93.0	322
(2) 09/24/92	7140	29.33	12.18	0.0	139	93.7	399
(3) 10/08/92	7031	28.73	12.23	0.0	137	93.0	321
(4) 10/22/92	5556	23.57	11.77	0.1	168	93.0	387
PD x VAR							
1 x 1	5707	25.07	11.73	0.0	124	92.2	433
1 x 2	8128	33.38	12.16	0.0	130	93.6	370
1 x 3	8040	30.12	13.36	2.2	133	90.1	223
1 x 4	7482	28.78	12.96	0.7	112	96.0	264
2 x 1	5470	24.22	11.30	0.0	141	92.4	542
2 x 2	8287	34.74	12.00	0.0	140	94.2	425
2 x 3	7165	28.32	12.70	0.0	144	92.9	320
2 x 4	7639	30.02	12.73	0.0	133	95.5	307
3 x 1	5744	25.08	11.48	0.0	134	91.5	406
3 x 2	7685	31.02	12.43	0.0	139	94.3	288
3 x 3	6784	27.38	12.43	0.0	135	92.1	300
3 x 4	7912	31.44	12.58	0.0	140	94.0	289
4 x 1	4734	20.90	11.38	0.0	172	91.0	404
4 x 2	5795	24.35	11.89	0.0	152	93.1	338
4 x 3	5552	23.24	11.92	0.5	179	93.4	422
4 x 4	6144	25.80	11.88	0.0	169	94.7	385

TEST B193. EFFECTS OF VARIETY x DATE OF PLANTING ON WHITEFLY INFESTATION, BRAWLEY, CA., 1992-93 (cont.)

Treatment	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
Grand Mean	6766.7	27.74	12.16	0.2	142.3	93.18	357.1
LSD (.05) - PD x V							
C.V. (%) - PD x V	13.6	13.01	6.87	466.8	9.5	3.28	38.9
F value - PD	48.1**	46.80**	2.56NS	2.1NS	23.1**	0.70NS	1.8NS
F value - V	24.7**	16.60**	10.77**	2.4NS	2.1NS	6.11**	4.9**
F value - PD x V	1.3NS	1.27NS	0.86NS	1.5NS	1.9NS	0.66NS	1.1NS

Note: Strain B of whitefy does not vector LIYV but may cause direct feeding injury. Four dates of planting were used to monitor whitefly populations on sugarbeet and to see if planting date caused significant differences in whitefy populations. Whitefly data were inconclusive, but trial was kept to see if differences occurred for varieties x dates of planting. Trial was at south edge of Block J and appeared to have a very high N status.

TEST B293.[1,2] EVALUATION OF DATE OF HARVEST x VARIETY ON PERFORMANCE UNDER RHIZOMANIA
BRAWLEY, CA., 1992-93

3 harvest dates x 12 varieties x 6 reps (Split-plot)[3]
1-row plots, 14 ft. long

Planted: September 24, 1992
Harvested: April 15, May 12, & July 1, 1993

	Acre Yield			Root	Stand	Harvest	Beets/	Clean		
	Sugar	Beets	Sucrose	Rot[4]	Count	Count	100'	Beets	NO3-N	Bolting
	Lbs	Tons	%	%	No.	No.	No.	%	ppm	%
HYBRID SET (Varieties 1-6)										
Treatment										
Harvest Date										
(1) 04/15/93	3350	11.92	13.83	3.29	22	21	156	90.4	119.7	0.0
(2) 05/12/93	2467	10.00	12.27	19.99	21	17	148	86.9	107.1	0.0
(3) 07/01/93	1316	6.27	7.39	64.31	21	8	153	84.9	180.0	0.0
Varieties										
(5) R280H68	3226	12.98	12.21	21.87	23	17	161	87.9	207.7	0.0
(3) Rima	3077	11.37	13.16	15.81	21	18	150	88.4	213.8	0.0
(6) 2915H68	2591	10.64	11.85	23.03	22	17	159	87.2	187.6	0.0
(4) Rhizoguard	2495	9.33	13.38	28.85	20	14	145	89.2	116.6	0.0
(2) HH 41	1536	6.22	8.84	44.82	21	12	152	85.6	34.9	0.0
(1) US H11	1343	5.86	7.56	40.81	21	12	148	86.0	53.1	0.0
HD x VAR										
1 x 1	2492	9.98	12.24	1.29	21	21	152	91.3	89.2	0.0
1 x 2	2336	8.74	13.21	7.72	22	21	158	89.2	62.3	0.0
1 x 3	4014	13.01	15.19	-2.90	21	22	152	91.3	177.8	0.0
1 x 4	3219	11.05	14.50	9.87	20	18	145	91.5	72.5	0.0
1 x 5	4460	16.14	13.78	3.98	22	21	158	90.2	206.8	0.0
1 x 6	3581	12.62	14.10	-0.20	24	24	171	89.1	109.8	0.0
2 x 1	1537	7.06	10.44	24.99	21	15	146	84.8	70.1	0.0
2 x 2	2250	9.21	12.34	34.49	21	14	151	88.0	29.5	0.0
2 x 3	2966	11.35	13.02	7.56	21	20	151	88.9	151.8	0.0
2 x 4	2494	9.84	13.12	20.89	19	15	138	87.9	114.8	0.0
2 x 5	2809	10.52	13.05	17.66	22	18	155	86.5	110.9	0.0
2 x 6	2746	12.02	11.62	14.36	21	18	146	85.0	165.7	0.0

TEST B293.[1,2] EVALUATION OF DATE OF HARVEST x VARIETY ON PERFORMANCE UNDER RHIZOMANIA
BRAWLEY, CA., 1992-93
(cont.)

	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot[4] %	Stand Count No.	Harvest Count No.	Beets/ 100' No.	Clean Beets %	NO3-N ppm	Bolting %
HYBRID SET (Varieties 1-6) (cont.)										
HD x VAR (cont.)										
3 x 1	0	0.55	0.00	96.14	21	1	146	82.0	0.0	0.0
3 x 2	22	0.71	0.96	92.24	21	2	146	79.6	12.8	0.0
3 x 3	2250	9.75	11.26	42.76	20	12	145	85.0	311.8	0.0
3 x 4	1772	7.09	12.52	55.79	21	9	152	88.3	162.3	0.0
3 x 5	2408	12.28	9.80	43.98	24	13	169	86.8	305.3	0.0
3 x 6	1445	7.27	9.82	54.92	22	10	158	87.6	287.5	0.0
Grand Mean	2377.9	9.40	11.16	29.20	21.3	15.2	152.4	87.4	135.6	0.0
LSD (.05)	1026.0	3.82	1.25	15.00	3.3	3.9	23.6	3.9	85.8	0.0
C.V.(%) - HDxV	37.6	35.29	9.73	44.66	13.5	22.5	13.5	3.9	55.0	0.0
F value - HD	8.4**	5.22*	188.19**	83.58**	1.4NS	112.6**	1.4NS	14.0**	9.4**	0.0
F value - V	13.8**	13.37**	88.01**	13.76**	1.6NS	10.6**	1.6NS	3.0*	20.3**	0.0
F value - HDxV	1.1NS	2.21*	37.31**	5.04**	0.6NS	4.0**	0.6NS	2.6**	4.5**	0.0
OPEN-POLLINATED SET (Varieties 7-12)										
Treatment										
Harvest Date										
(1) 04/15/93	5940	19.77	14.76	-1.61	23	24	167	89.9	79.0	2.8
(2) 05/12/93	5356	19.38	13.71	4.06	23	22	166	85.8	49.9	4.5
(3) 07/01/93	4687	18.93	12.48	38.74	23	14	166	90.1	119.6	5.7
Varieties										
(7) R222R4	7863	30.20	12.86	2.61	24	23	169	89.6	178.2	21.0
(10) R239C8	6134	22.25	13.68	12.81	24	21	169	89.6	68.5	0.6
(12) R280	5609	19.43	14.01	12.52	24	21	171	90.3	66.3	0.0
(11) R276Y	5415	19.26	13.78	15.72	23	19	165	90.7	83.6	0.0
(9) R232	3761	14.17	13.15	18.08	23	18	161	83.7	66.4	3.9
(8) R228	3185	10.83	14.40	20.65	23	19	165	87.8	34.0	0.5

TEST B293.[1,2] EVALUATION OF DATE OF HARVEST x VARIETY ON PERFORMANCE UNDER RHIZOMANIA
BRAWLEY, CA., 1992-93
(cont.)

	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot[4] %	Stand Count No.	Harvest Count No.	Beets/ 100' No.	Clean Beets %	NO3-N ppm	Bolting %
OPEN-POLLINATED SET (Varieties 7-12) (cont.)										
Treatment (cont.)										
HD x VAR										
1 x 7	8849	29.99	13.89	-9.49	23	25	164	89.8	167.1	13.0
1 x 8	3410	10.68	15.51	1.09	24	24	174	88.9	19.9	0.0
1 x 9	4024	13.97	14.21	6.92	24	22	171	81.9	68.3	3.9
1 x 10	6973	23.00	14.68	8.42	24	22	169	92.8	74.3	0.0
1 x 11	6013	19.77	14.65	-6.58	22	23	157	93.6	88.7	0.0
1 x 12	6770	21.20	15.59	-9.98	23	25	165	92.4	55.4	0.0
2 x 7	8174	31.24	12.93	-2.85	24	25	174	88.8	123.7	24.6
2 x 8	3288	10.95	14.58	13.43	23	20	163	85.2	12.6	0.0
2 x 9	3515	13.56	13.08	0.72	20	19	140	81.6	41.6	2.2
2 x 10	5737	20.48	13.99	-0.91	24	24	171	84.9	31.0	0.0
2 x 11	6287	22.37	14.07	4.97	25	24	176	86.5	56.3	0.0
2 x 12	5137	17.68	13.58	9.00	24	21	173	87.8	34.0	0.0
3 x 7	6967	29.37	11.77	20.17	24	19	168	90.3	243.8	25.3
3 x 8	2857	10.85	13.11	47.44	22	12	158	89.1	69.4	1.5
3 x 9	3744	14.99	12.16	46.60	24	13	170	87.7	89.2	5.6
3 x 10	5693	23.29	12.36	30.92	23	16	167	91.0	100.3	1.9
3 x 11	3945	15.66	12.62	48.77	23	12	161	91.8	105.8	0.0
3 x 12	4919	19.42	12.85	38.53	25	15	175	90.8	109.4	0.0
Grand Mean	5327.8	19.36	13.65	13.73	23.3	20.1	166.5	88.6	82.8	4.3
LSD (.05)	1580.0	5.92	1.14	19.47	2.9	4.4	20.9	4.0	56.7	5.4
C.V.(%) - HDxV	25.8	26.58	7.27	123.31	10.9	19.2	10.9	4.0	59.5	108.4
F value - HD	2.9NS	0.13NS	22.99**	105.80**	0.0NS	42.6**	0.0NS	16.11**	8.6**	2.8NS
F value - V	27.1**	30.67**	5.78**	2.47*	0.8NS	3.7**	0.8NS	9.90**	18.1**	55.9**
F value - HDxV	1.0NS	0.79NS	0.47NS	1.23NS	1.9NS	1.3NS	1.9NS	1.76NS	0.6NS	2.2*

TEST B293.[5] EVALUATION OF DATE OF HARVEST x VARIETY ON PERFORMANCE UNDER RHIZOMANIA
BRAWLEY, CA., 1992-93

12 varieties x 6 replications (Split-plot)
1-row plots, 14 ft. long

Planted: September 24, 1992
Harvested: April 15, 1993

Variety	Sodium ppm	Potassium ppm	Amino Nitrogen ppm	Recov. Sugar lbs/acre	Recov. Sugar %	Recov. Sugar lbs/ton	Imp. Value	Known Sugar Loss lbs/acre
HYBRIDS (Varieties 1-6)								
US H11	1170	2894	136	2123	84.0	207	12619	369
HH 41	1501	2928	137	1974	83.9	223	13876	362
Rima	1246	2473	262	3516	87.0	265	13033	498
Rhizoguard	1094	2388	205	2835	87.8	255	11748	384
R280H68	1309	2581	236	3856	85.5	236	13278	604
2915H68	1707	2966	199	3038	83.5	236	15283	543
OPEN-POLLINATED (Varieties 7-12)								
R222R4	825	2792	424	7238	84.5	236	13893	1210
R228	1038	2792	186	3069	87.8	273	12379	341
R232	984	2618	183	3564	87.5	249	11730	459
R239C8	776	3418	197	6119	86.5	254	13131	854
R276Y	1246	3030	288	5265	84.4	249	14668	748
R280	862	2728	245	6039	88.0	275	12162	731
Mean	1146.4	2800.7	224.8	4053.0	85.9	246.4	13150.0	592.0
LSD (.05)	689.7	719.6	109.5	1633.3	5.2	31.7	4195.6	239.5
C.V. (%)	52.0	22.2	42.1	34.8	5.3	11.1	27.6	35.0
F value	1.3NS	1.2NS	4.0**	8.7**	0.9NS	3.3**	0.6NS	9.3**

[5]Na, K and NH_2-N data were collected only for harvest date 1 (April 15, 1993) of test B293. See test B293 split-plot for remainder of data.

TEST B293.[1,2] EVALUATION OF DATE OF HARVEST x VARIETY ON PERFORMANCE UNDER RHIZOMANIA
BRAWLEY, CA., 1992-93
(cont.)

[1]Harvest Date 2 (May 12) closely corresponds to the harvest date of Test B793. Except for effects of rhizomania, performance in tests B293 and B793 (without rhizomania) should be similar.

[2]Rhizomania infection was severe at top of field to moderate at bottom of field. Root symptoms were moderate with little bearding; most symptoms involved internal vascular discoloration and necrosis followed by root rot as soils warmed. R222R4 always showed the most vigorous growth. Cyst nematode were also prevalent in this test.

[3]Two sets of 6 varieties were maintained together. These two sets would be 3 harvest dates x 6 replications split-plots. However, treatment means can be compared across these sets.

[4]% rot was calculated from the difference between stand counts and harvest counts. Negative values reflect experimental error in making these counts and probably are primarily due to doubles counted as a single plant during stand counts.

Conclusion: (Also see Test B692, p.63, 1992 Sugarbeet Research Report.) Test B293 was grown in same field plot area as Test B692. Consequently, effects of rhizomania were more severe in 1993 than in 1992. The results suggest that rhizomania can be devastating in the Imperial Valley. Effects of severe infestation showed in the fall growth and resulted in lower yield in the early harvest period. As conditions warmed and the beets were placed under increasing stress, they ceased to grow and accumulate sugar. As the season progressed, more and more root rot occurred. By July, highly susceptible varieties like US H11 had completely died (rotted). Moderately susceptible varieties also showed reduced yields and high levels of root rot. Only R222R4 with germplasm derived from wild beet (Beta maritima) has near normal yields and resists high levels of root rot.

TEST B793. NON-DISEASED CHECK FOR RHIZOMANIA TEST B293 CORRESPONDING TO SECOND DATE OF HARVEST, BRAWLEY, CA., 1992-93

8 entries x 8 replications, RCB
1-row plots, 27 ft. long (16 blocks)

Planted: September 24, 1992
Harvested: May 18, 1993

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
US H11	L113401	7813	29.64	13.24	0.0	153	90.1	148
HH 41	L41138	8907	30.58	14.59	0.7	150	92.7	69
Rima	SES	8808	29.76	14.78	0.9	149	94.4	110
Rhizoguard	Holly L893301	8510	30.06	14.20	2.2	143	96.0	81
R280H68	1867Raa x R080	8573	31.14	13.73	4.1	143	93.7	109
2915H68	1867Raa x RZM 1913,1915	9654	34.06	14.17	2.5	147	93.2	79
R239C8	RZM R139C7	8589	32.45	13.24	25.9	148	94.4	103
R276Y	RZM-BYV-ER R076	8651	30.89	14.00	1.0	137	96.4	105
Mean		8688.2	31.07	14.00	4.7	146.3	93.9	100.3
LSD (.05)		1024.5	3.11	0.98	4.8	12.4	2.5	45.6
C.V. (%)		11.7	9.95	6.98	102.6	8.5	2.7	45.2
F value		2.0NS	1.91NS	2.69*	26.5**	1.3NS	4.9**	2.4*

[1]1867R = Rz version of popn-767. R080 = C54Rz. 1913,1915 = MM,S^f,A:aa,Rz population. R139C7 = 2 additional cycles of selection from C39R5. R076 = Rz version of C31/6. R139C7 and R076 are open-pollinated lines.

TEST B493. EVALUATION OF EXPERIMENTAL HYBRIDS, BRAWLEY, CA., 1992-93

32 entries x 8 replications, RCB (equalized)
1-row plots, 27 ft. long (16 blocks)

Planted: September 23, 1992
Harvested: May 14, 1993

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
Checks								
HH 41	L41138	8733	30.45	14.36	0.0	138	96.4	83
US H11	L113401	6467	24.81	12.97	0.3	138	93.2	128
mm CMS x MM								
R282H37	9807HO x R176-43,-89	10717	38.24	14.02	4.0	141	96.1	67
2915H39	C762-17CMS x RZM 1913,1915	9958	36.07	13.83	0.0	143	94.4	91
R278H37	C306CMS x R078	9956	34.52	14.49	3.3	141	95.3	94
2915H18	790-68H26 x RZM 1913,1915	9772	32.81	15.01	2.9	141	95.5	77
R278H39	C762-17CMS x R078	9224	32.15	14.35	1.4	140	95.6	81
R282H18	790-68H26 x R176-43,-89	9014	30.16	14.91	11.9	125	95.0	89
R276H23	309H37 x R076	8694	29.41	14.79	1.9	143	94.9	73
R276H18	790-68H26 x R076	8453	30.24	13.98	4.1	137	94.9	97
R278H18	790-68H26 x R078	7900	25.71	15.52	7.6	133	94.7	56
N203H18	790-68H26 x C603,C603-1	6068	25.69	11.74	0.0	133	92.2	185
mm CMS x R80								
R080H30	C790-15aa x R080	9935	33.59	14.76	2.0	133	94.5	84
R280H37	9807HO x R080	9480	34.09	13.96	1.7	137	96.4	102
R280H33	C790-54aa x R080	9333	31.59	14.81	1.5	124	95.4	45
R280H50	1855-24HO x R080	9031	29.21	15.48	5.6	150	93.2	49
R280H52	1852- 7HO x R080	8968	30.44	14.76	0.0	131	95.2	71
R280H39	C762-17CMS x R080	8921	32.76	13.67	0.6	137	95.0	73
R280H89	C790-68CMS x R080	8551	28.40	15.07	2.6	147	94.7	66
R280H36	0833HO x R080	8531	29.22	14.55	1.4	135	95.9	66

TEST B493. EVALUATION OF EXPERIMENTAL HYBRIDS, BRAWLEY, CA, 1992-93

(cont.)

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
mm CMS x R80 (cont.)								
R280H53	1852-52HO x R080	8371	28.23	14.86	0.7	134	95.2	59
R280H20	309H3 x R080	8242	27.58	14.93	0.9	143	95.2	66
R280H8	546H3 x R080	8034	29.09	13.76	1.4	137	95.8	133
R280H51	1855-59HO x R080	8007	27.18	14.74	1.3	142	94.4	72
R280H18	790-68H26 x R080	7866	26.72	14.74	5.0	137	94.5	90
R280H22	0722HO x R080	7857	27.82	14.15	1.6	141	93.1	107
R280H29	C790- 6aa x R080	7756	26.18	14.80	1.9	124	94.4	48
popn-aa x R80								
R280H58	1859Raa x R080	9384	30.63	15.33	3.4	124	96.4	63
R280H64	1864aa x R080	9302	32.56	14.26	2.3	122	95.0	96
R280H93	1890aa x R080	9105	29.71	15.31	2.1	135	95.8	50
R280H68	1867Raa x R080	8730	30.66	14.21	2.3	136	96.2	99
R280H65	1865aa x R080	8654	29.88	14.47	3.3	139	94.7	74
Mean		8719.1	30.18	14.46	2.5	136.2	95.0	82.3
LSD (.05)		644.5	3.02	0.69	2.8	12.1	1.8	46.1
C.V. (%)		10.6	10.17	4.82	115.3	9.0	1.9	56.9
F value		8.7**	8.22**	9.33**	5.9**	2.4**	2.4**	3.0**

[1]790-68H26 = C309CMS x C790-68. 309H37 = C306CMS x C309. 9807HO = reselection of C306CMS. 546H3 = C562CMS x C546. C309H3 = C562CMS x C309. 1859 = popn-C859. 1864,1865,1867,1890 = Rz versions of populations -764, -C310, -767, and -790. R080, R076, R078, R176-43, R176-89 = Rz versions of C54, C31/6, C46/2, C31-43, C31-89. 1913,1915 = MM, S^f, A:aa, Rz populations. C603,C603-1 = cyst nematode resistant lines.

TEST B593. AREA 5 CODED VARIETY TRIAL, BRAWLEY, 1992-93

32 entries x 8 replications, RCB (equalized)
1-row plots, 27 ft. long

Planted: September 23, 1992
Harvested: May 17, 1993

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.[2]	Clean Beets %	NO3-N ppm
A5-32[1]	R278H39	USDA	11432	36.75	15.53	2.2	150	91.8	57
A5-01	HM 3013	Hill M-H	11237	35.83	15.70	0.3	144	92.5	71
-22	HM 3012	Hill M-H	11029	35.48	15.56	0.3	150	94.6	37
-28	HM 3005	Hill M-H	10800	33.98	15.91	0.0	143	93.4	43
-29	2BG6067	Betaseed	10808	35.59	15.17	0.0	137	92.8	71
-26	H92566	Spreckels	10947	36.48	15.02	0.0	151	94.2	76
-14	9BG6346	Betaseed	10715	35.45	15.12	0.0	151	95.2	74
-07	HH 51	Holly	10567	34.66	14.99	0.0	149	95.7	78
-10	93HX01	Holly	10450	33.80	15.47	0.0	130	94.6	84
-05	HM 3022	Hill M-H	10298	33.60	15.32	0.3	149	93.4	65
-20	H90636	Spreckels	10242	32.62	15.70	0.4	150	94.3	56
-03	Rhizoguard	Holly	10007	31.97	15.65	0.7	142	95.9	53
-18	92HX2	Holly	9916	31.42	15.80	0.0	150	94.1	53
-04	2BG6068	Betaseed	10039	32.78	14.97	0.3	135	91.9	97
-08	SS-IV1	Spreckels	9894	32.27	15.30	0.0	144	93.1	47
-06	4823	Betaseed	9956	32.46	15.33	0.6	153	92.8	60
-31	2BG6069	Betaseed	9821	32.33	15.22	0.0	152	92.8	59
-21	2BG6066	Betaseed	9704	32.58	14.92	0.0	147	93.5	68
-09	90-1459-0189	Holly	9529	30.84	15.45	0.3	139	94.5	62
-24	H89299	Spreckels	9538	30.66	15.59	0.0	141	94.4	62

TEST B593. AREA 5 CODED VARIETY TRIAL, BRAWLEY, 1992-93

(cont.)

Code No.	Variety	Source	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.[2]	Clean Beets %	NO3-N ppm
-02	0BG6392	Betaseed	9649	32.01	15.05	0.0	131	92.6	80
-23	HM 3019	Hill M-H	9363	29.80	15.74	0.9	148	93.9	38
-15	HH 41	Holly	9411	31.46	14.97	0.0	156	94.5	70
-11	HH 77	Holly	9544	33.30	14.35	0.0	153	93.0	76
-27	2BG6079	Betaseed	9218	29.45	15.62	0.3	146	93.8	37
-30	0BG6178	Betaseed	9336	30.39	15.37	0.3	143	91.2	41
-13	2BG6345	Betaseed	9446	32.51	14.57	0.0	73	95.1	81
-25	HH 66	Holly	9151	29.41	15.55	0.0	146	93.8	45
-17	90-1459-0110	Holly	9059	28.29	16.05	0.0	149	93.3	38
-19	HH 79	Holly	8964	29.28	15.31	0.0	163	92.7	36
-12	HM 3031	Hill M-H	9008	28.20	15.99	0.0	155	93.0	47
-16	US H11	USDA	8167	28.66	14.22	0.0	153	91.7	108
Mean			9913.9	32.32	15.33	0.2	144.4	93.6	61.4
LSD (.05)			876.0	2.82	0.58	0.7	9.5	2.2	40.9
C.V. (%)			9.0	8.85	3.81	335.6	6.7	2.4	67.6
F value			5.8**	5.76**	4.50**	2.8**	18.8**	2.1**	1.6NS

[1]Code 32, R278H39 is a USDA filler. R278H39 = C762-17CMS x R078

[2]Beets/100' x 174 = beets/acre, or beets/100'x 430 = beets/h. Test mean would be 25,000 beets/acre or 62,000 beets/h.

TEST B593. AREA 5 CODED VARIETY TRIAL, BRAWLEY, 1992-93

(cont.)

Variety	Sodium ppm	Potassium ppm	Amino Nitrogen ppm	Recov. Sugar lbs/acre	Recov. Sugar %	Recov. Sugar lbs/ton	Imp. Value	Known Sugar Loss lbs/acre
R278H39	307	2950	354	10138	88.6	275	11811	1294
HM 3013	332	2590	364	10040	89.4	281	11097	1198
HM 3012	281	2546	363	9878	89.6	279	10797	1151
HM 3005	286	2551	303	9751	90.3	288	10258	1049
2BG6067	296	2858	312	9619	88.9	270	11149	1190
H92566	384	2902	430	9558	87.3	262	12684	1389
9BG6346	374	2648	360	9510	88.7	268	11346	1206
HH 51	318	2654	349	9416	89.1	273	11064	1151
93HX01	323	2695	397	9266	88.6	275	11640	1185
HM 3022	311	2620	355	9192	89.2	273	11007	1107
H90636	287	2510	380	9180	89.6	281	10890	1063
Rhizoguard	304	2664	384	8909	89.0	279	11372	1098
92HX2	287	2652	327	8903	89.7	284	10740	1014
2BG6068	307	2925	353	8890	88.5	271	11736	1149
SS-IV1	310	2502	329	8888	89.7	275	10462	1006
4823	304	2685	420	8815	88.5	271	11767	1142
2BG6069	292	2729	359	8730	88.9	271	11253	1090
2BG6066	287	2860	393	8547	88.0	263	11884	1157
90-1459-0189	263	2449	380	8540	89.6	277	0651	989
H89299	342	2520	391	8511	89.2	278	11211	1027
OBG6392	326	2808	430	8481	87.7	264	12247	1168
HM 3019	251	2473	381	8404	89.8	283	10678	959
HH 41	310	2544	366	8381	88.8	267	10925	1030
HH 77	242	2808	446	8339	87.3	251	12101	1205

TEST B593. AREA 5 CODED VARIETY TRIAL, BRAWLEY, 1992-93

(cont.)

Variety	Sodium ppm	Potassium ppm	Amino Nitrogen ppm	Recov. Sugar lbs/acre	Recov. Sugar %	Recov. Sugar lbs/ton	Imp. Value	Known Sugar Loss lbs/acre
2BG6079	274	2569	293	8326	90.2	282	10161	892
0BG6178	263	2658	390	8310	89.0	274	11268	1026
2BG6345	295	2937	404	8249	87.2	255	12216	1197
HH 66	309	2368	342	8246	90.1	280	10250	905
90-1459-0110	239	2308	342	8217	90.7	292	9854	842
HH 79	232	2562	436	7963	88.8	272	11357	1000
HM 3031	299	2610	524	7945	88.2	282	12553	1063
US H11	352	2899	417	7101	86.8	247	12442	1065
Mean	299.5	2657.9	377.3	8820.1	88.9	273.2	11277.2	1093.9
LSD (.05)	63.0	256.4	79.4	824.2	1.5	13.4	1228.0	153.7
C.V. (%)	21.4	9.8	21.4	9.5	1.7	5.0	11.1	14.3
F value	2.4**	3.4**	2.7**	5.4**	3.2**	4.4**	2.7**	4.5**

Footnote: R278H39 is USDA filler; R78 = Rz version of C46/2. Entry 13 had poor stands. Yield was adjusted for missing feet of row but because of extent of gaps, should be considered an estimate. Poast was applied post emergence. Thiodan and Lorsban were applied for flea beetle control. Powdery mildew was not controlled and incidence was moderate at harvest. Empoasca were light but a heavy infestation of mites occurred just prior to harvest. The test was off water for just three weeks prior to harvest and the beets were lush. Test appeared to be uniform and reliable.

TEST B993. HYBRID EVALUATION OF SELECTED PROGENY FAMILIES FROM POPN-864 AND R80, BRAWLEY, CA., 1992-93

24 entries x 8 replications, RCB
1-row plots, 18 ft. long (24 blocks)

Planted: September 24, 1992
Harvested: May 20, 1993

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
Checks								
HH 41	L41138	9545	34.02	14.06	0.0	140	95.0	160
R276H20	309H3 x R076	8936	33.48	13.30	3.0	144	94.4	248
R278H20	309H3 x R078	8553	30.37	13.98	2.8	145	94.0	77
US H11	L113401	7456	26.29	14.19	0.0	142	91.0	99
R80 progenies								
R280-28H20	309H3 x R080-28	9312	31.29	14.87	0.9	145	93.7	68
R280-56H20	309H3 x R080-56	9147	32.16	14.24	0.5	137	94.0	178
R280-35H20	309H3 x R080-35	8974	31.15	14.37	1.5	140	93.5	77
R280-45H20	309H3 x R080-45	8970	30.34	14.78	0.0	138	94.6	128
R280H20	309H3 x R080	8715	30.42	14.29	3.0	144	94.6	77
R280-1H20	309H3 x R080-1	8603	30.23	14.27	0.4	143	94.8	184
R280-80H20	309H3 x R080-80	8476	29.69	14.26	1.8	138	93.4	155
R280-79H20	309H3 x R080-79	7990	27.29	14.63	0.0	145	93.9	157
R280-13H20	309H3 x R080-13	7945	28.51	13.94	0.9	137	95.4	161
864 progenies								
R280H62- 5	0864- 5aa x R080	9507	33.85	14.05	2.6	108	95.0	125
R280H62- 8	0864- 8aa x R080	9400	33.35	14.06	3.9	124	94.7	149
R280H62-28	0864-28aa x R080	9367	33.44	14.04	2.1	104	93.7	168
R280H68	1867Raa x R080	9000	32.58	13.77	4.6	136	94.5	235
R280H62-14	0864-14aa x R080	8942	31.74	14.02	8.0	128	94.9	203
R280H62-34	0864-34aa x R080	8895	32.91	13.53	3.7	129	94.7	256

TEST B993. HYBRID EVALUATION OF SELECTED PROGENY FAMILIES FROM POPN-864 AND R80, BRAWLEY, CA., 1992-93

(cont.)

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100′ No.	Clean Beets %	NO3-N Mean
864 progenies (cont.)								
R280H62- 1	0864- 1aa x R080	8893	32.28	13.75	8.7	124	93.9	159
R280H62-40	0864-40aa x R080	8861	33.13	13.36	2.8	120	94.8	205
R280H62-19	0864-19aa x R080	8823	31.64	14.00	2.4	123	93.0	98
R280H64	1864aa x R080	8386	32.50	12.88	2.2	129	93.9	237
R280H62-25	0864-25aa x R080	8169	29.47	13.81	0.6	104	94.2	235
Mean		8785.9	32.34	14.02	2.4	131.9	94.1	159.8
LSD (.05)		1188.4	3.34	0.94	3.2	14.7	1.8	121.2
C.V. (%)		13.7	10.78	6.81	136.7	11.3	1.9	76.8
F value		1.5NS	2.96**	1.81*	4.0**	6.0**	2.0**	1.8*

[1]309H3 = C562CMS x C309. 1864 = early version of popn-867. 1867R = Rz version of popn-767. 0864-#'s = half-sib families selected from popn-864 on basis of per se performance under diseased and nondiseased conditions. R080 = C54Rz. R080-#'s = half-sib families selected from R80 on the basis of per se performance under nondiseased, virus yellows, and rhizomania condtions. R076 = C31/6Rz. R078 = C46/2Rz.

TEST B893-1[1]. HYBRID EVALUATION OF SELECTED PROGENY FAMILIES FROM POPNS-909,-911,-913,-915
BRAWLEY, CA., 1992-93

16 entries x 8 replications, RCB (equalized)
1-row plots, 18 ft. long (24 blocks)

Planted: September 24, 1992
Harvested: May 19, 1993

Variety	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
2915H20	309H3 x RZM 1913,1915	8677	30.69	14.24	0.0	140	94.1	133
0909-34H20	309H3 x 8909A-34	9225	32.28	14.32	0.5	146	94.8	98
0909-37H20	309H3 x 8909A-37	9653	34.38	14.08	0.0	141	92.8	108
2911-4H20	309H3 x RZM 1911-4	8170	27.41	14.90	0.0	146	92.8	91
2911-12H20	309H3 x RZM 1911-12	8854	30.89	14.32	0.5	140	93.9	67
2911-14H20	309H3 x RZM 1911-14	8667	29.38	14.71	0.5	144	92.8	104
2911-50H20	309H3 x RZM 1911-50	9849	33.70	14.61	2.0	136	94.6	117
2913-5H20	309H3 x RZM 1913-5	8486	30.11	14.11	0.0	128	93.4	107
2913-18H20	309H3 x RZM 1913-18	8672	31.03	14.03	0.0	140	93.1	104
2913-22H20	309H3 x RZM 1913-22	8151	29.38	13.89	0.0	144	88.6	130
2913-25H20	309H3 x RZM 1913-25	8747	29.87	14.64	0.0	151	92.2	46
2911-24H20	309H3 x 0911-24	7143	26.58	13.36	0.0	145	95.0	92
2913-9H20	309H3 x 0913-9	8706	29.70	14.64	0.0	141	92.8	80
2915-4H20	309H3 x 0915-4	9352	31.00	15.08	0.0	145	93.6	77
2915-7H20	309H3 x 0915-7	9094	31.11	14.60	0.0	143	92.6	77
2915-46H20	309H3 x 0915-46	7803	27.23	14.27	0.0	142	92.0	104
Mean		8703.0	30.30	14.36	0.2	142.1	93.1	96.0
LSD (.05)		730.6	2.99	1.05	1.0	11.8	3.1	61.9
C.V. (%)		12.0	9.98	7.36	445.9	8.4	3.4	65.1
F value		3.4**	3.98**	1.29NS	2.2**	1.5NS	1.8*	1.1NS

[1]TEST B893. HYBRID EVALUATION OF SELECTED PROGENY FAMILIES FROM MM, S^f, A:aa, Rz POPNS.
48 entries x 8 replications, Incomplete blocks with 3 subsets each with 16 varieties x 8 reps, RCB.
Thus, means across tests B893-1,-2,-3 can be compared.

Mean	8674.5	30.18	14.38	0.4	137.3	93.2	94.8
LSD (.05)	1053.9	3.08	1.02	1.2	12.8	2.5	70.0
C.V. (%)	12.4	10.38	7.21	286.6	9.5	2.7	75.0
F value	2.1**	2.57**	1.22NS	2.7**	2.1**	1.6**	0.9NS

TEST B893-2. HYBRID EVALUATION OF SELECTED PROGENY FAMILIES FROM POPNS-911,-912,-913
BRAWLEY, CA., 1992-93

16 entries x 8 replications, RCB (equalized)
1-row plots, 18 ft. long (24 blocks)

Planted: September 24, 1992
Harvested: May 19, 1993

Variety	Description[3]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
US H11	L113401	7534	26.33	14.31	0.0	140	91.5	149
2915H65	1865aa x RZM 1913,1915	9445	32.77	14.41	1.0	139	93.8	145
2865H13	1913aa x 1865,1865-#	8898	31.72	14.06	0.0	135	93.5	122
2865H43-4	1911-4aa x 1865,1865-#	8217	28.76	14.26	0.0	128	91.2	78
2865H43-12	1911-12aa x 1865,1865-#	8243	30.20	13.68	0.0	130	93.4	136
2865H43-14	1911-14aa x " "	8999	30.62	14.70	2.0	138	92.6	94
2865H43-50	1911-50aa x " "	9183	31.26	14.68	3.6	137	94.0	74
2865H44- 3	1912- 3aa x " "	8519	29.30	14.57	0.5	128	93.5	56
2865H44-11	1912-11aa x " "	8399	29.41	14.26	0.7	115	93.7	65
2865H45- 5	1913- 5aa x " "	8860	31.22	14.21	0.0	131	93.1	88
2865H45-18	1913-18aa x " "	8960	30.24	14.83	2.1	134	93.6	63
2865H45-22	1913-22aa x " "	8391	29.20	14.36	0.5	135	92.0	90
2865H45-25	1913-25aa x " "	8840	30.91	14.33	0.0	134	93.1	87
2865H46- 1	0911- 1aa x " "	8913	32.47	13.75	0.0	141	93.6	108
2865H46-4B	0911-4(B)aa x "	8247	28.93	14.25	0.5	136	93.7	116
2865H46-24	0911-24aa x " "	8332	29.14	14.30	1.1	140	92.8	104
Mean		8623.6	30.16	14.31	0.7	133.8	93.1	98.5
LSD (.05)		896.2	2.86	0.88	1.5	12.4	1.7	65.9
C.V. (%)		10.5	9.58	6.19	197.3	9.4	1.9	67.6
F value		2.2*	2.49**	0.97NS	3.9**	2.1NS	1.8NS	1.5NS

[2]309H3 = C562CMS x C309. Progeny families 8909-#'s thru 0915-#'s from early cycles of progeny tests. Selected progeny lines increased in greenhouse isolation chambers and crossed to C309H3 tester. RZM means line was reselected for resistance to rhizomania using mother roots. aa = genetic male sterile plants used as females.

[3]1865,1865-# = Rz version of popn-C310 (-755), but with a large component of line C309. 1911-#'s thru 1913-#'s = selected half-sib progeny families from popns-911,-912, and -913.

TEST B893-3. HYBRID EVALUATION OF SELECTED PROGENY FAMILIES FROM POPNS-913,-915
BRAWLEY, CA., 1992-93

16 entries x 8 replications, RCB (equalized)
1-row plots, 18 ft. long (24 blocks)

Planted: September 24, 1992
Harvested: May 19, 1993

Variety	Description[4]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
HH 41	L41138	8915	31.26	14.26	0.0	144	94.3	110
2915H65	1865aa x RZM 1913,1915	8820	32.05	13.77	0.5	142	93.7	108
2865H15	1915aa x 1865,1865-#	8945	30.80	14.54	0.0	138	93.7	72
2865H47-6	0913-6aa x 1865,1865-#	8129	28.58	14.24	0.0	132	92.6	109
2865H47-9	0913-9aa x 1865,1865-#	8581	29.91	14.32	0.5	139	93.4	86
2865H48-1	0915-1aa x " "	8886	29.74	14.95	0.5	140	94.1	83
2865H48-4	0915-4aa x " "	8523	31.06	13.75	0.6	137	93.2	137
2865H48-6	0915-6aa x " "	7826	26.36	14.91	1.1	129	94.5	80
2865H48- 7	0915- 7aa x 1865,1865-#	8451	28.81	14.52	0.0	135	93.0	110
2865H48-16	0915-16aa x " "	9173	30.88	14.88	0.5	138	94.4	75
2865H48-22	0915-22aa x " "	9170	30.08	15.23	0.0	138	91.5	78
2865H48-23	0915-23aa x " "	8784	31.95	13.65	0.0	135	94.1	83
2865H48-24	0915-24aa x 1865,1865-#	8873	29.92	14.82	0.0	129	93.5	70
2865H48-27	0915-27aa x " "	8633	30.07	14.37	0.5	138	93.6	85
2865H48-34	0915-34aa x " "	9662	32.39	14.93	0.5	141	95.1	70
2865H48-46	0915-46aa x " "	7782	27.51	14.18	0.5	122	91.8	83
Mean		8697.0	30.09	14.46	0.3	136.0	93.5	89.9
LSD (.05)		1073.2	3.17	0.87	1.1	14.0	2.6	69.9
C.V. (%)		12.5	10.64	6.11	350.1	10.4	2.8	78.5
F value		1.6NS	2.12*	2.32**	0.7NS	1.3NS	1.1NS	0.6NS

[4]0913-#'s thru 0915-#'s = selected half-sib progeny families from popns-913,-915.

TEST B693. EVALUATION OF POPULATION HYBRIDS, BRAWLEY, CA, 1992-93

16 entries x 8 replications, RCB (equalized)
1-row plots, 27 ft. long (16 blocks)

Planted: September 24, 1992
Harvested: May 18, 1993

Variety	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/100' No.	Clean Beets %	NO3-N Mean
Checks								
HH 41	L41139	9673	33.84	14.29	0.0	149	93.7	80
US H11	L113401	7473	28.28	13.21	0.0	150	91.7	129
CMS x popn-913,-915								
2915H39	C762-17CMS x RZM 1913,1915	10565	37.36	14.14	0.0	143	91.2	85
2915H18	790-68H26 x RZM 1913,1915	10460	34.42	15.23	2.3	148	93.6	56
2915H89	C790-68CMS x RZM 1913,1915	9595	32.42	14.86	1.1	141	93.5	63
2915H26	C309CMS x RZM 1913,1915	9110	29.58	15.39	4.4	153	92.7	49
2915H20	309H3 x RZM 1913,1915	9013	31.14	14.50	0.0	149	94.8	69
popn-aa x popn-913,-915								
2915H65	1865aa x RZM 1913,1915	9541	32.85	14.52	0.6	150	94.3	89
2915H58	1859Raa x RZM 1913,1915	9460	32.36	14.55	0.3	148	95.2	67
2915H68	1867Raa x RZM 1913,1915	9173	32.27	14.24	2.5	150	94.1	78
2915H90	0790aa x RZM 1913,1915	8706	30.53	14.20	0.6	151	93.6	98
popn-915 x mm popns								
2890H15	1915aa x 1890,RZM1890	9587	32.60	14.70	0.4	144	93.9	73
2867H15	1915aa x 1867,1867R	9524	33.96	14.05	5.9	141	94.7	133
2865H15	1915aa x 1865,1865-#	9148	31.84	14.37	1.3	146	93.7	99
2859H15	1915aa x 1859,1859R	8733	31.36	13.90	0.7	139	94.2	87
N203H15	1915aa x C603,C603-1	6955	31.63	11.03	1.3	143	94.1	209
Mean		9169.7	32.28	14.20	1.3	146.4	93.7	91.4
LSD (.05)		766.7	3.64	0.70	1.8	8.7	1.9	48.3
C.V. (%)		11.9	11.40	5.01	138.3	6.0	2.0	53.4
F value		5.7**	2.57*	15.48**	6.7**	1.9NS	2.5**	5.1**

[1]790-68H26 = C309CMS x C790-68. 309H3 = C562CMS x C309. 1913,1915 = MM,S^f,A:aa,Rz population. 1859R = popn-C859. 0790 = popn-790(C5). 1867,1865,1890 = Rz versions of popns-767, -C310, -C790.

TEST R793. RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA
(IIRB RHIZOMANIA TEST), SALINAS, CA., 1993

16 entries x 8 replications, RCB (equalized)
1-row plots, 18 ft. (5.5 M) long, 71 cm wide

Planted: June 10, 1993
Harvested: November 18, 1993

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/ 100' No.	Powdery Mildew 10/06	RJAP %	CLS Score
Test R793-1									
Rizor	IIRB	4677	14.80	15.8	0.0	202	7.5	76.0	2.5
R039C5	Inc. R939C5	4458	15.05	14.8	0.6	243	2.6	75.9	1.5
C48 (KWS)	IIRB	4437	15.46	14.3	0.0	169	5.0	75.9	3.0
Stratos	IIRB	3746	12.92	14.4	0.0	238	4.1	75.7	5.9
Monodoro	IIRB	3475	12.46	13.9	0.0	211	4.6	76.4	1.6
Roxane	IIRB	2289	9.25	12.2	0.0	150	4.3	73.5	3.4
Accord	IIRB	2069	8.85	11.6	0.0	158	2.8	71.6	4.3
US H11	L113401 (April 1993)	1720	7.27	11.7	0.0	215	5.5	72.6	2.6
Test R793-2									
R222R4H20	87-309H3 x RZM R122R3	4721	17.29	13.6	0.0	251	8.3	74.7	1.6
2915H18	88-790-68H26 x 1913,1915	3763	13.06	14.4	0.0	250	5.5	75.0	2.9
R280H68	1867Raa x R080	3628	12.98	14.0	0.0	254	4.3	77.1	2.8
R282H18	88-790-68H26 xR176-43,-89	3551	12.51	14.2	0.0	229	4.8	76.0	3.1
R280H18	88-790-68H26 x R080	3417	11.56	14.8	0.0	257	5.0	76.0	3.9
R278H18	88-790-68H26 x R078	3370	11.28	14.9	0.0	220	4.8	77.6	4.4
Rhizoguard	L893301	3094	11.02	14.1	0.0	224	5.6	77.7	2.5
6770	% S check	1681	6.02	13.9	0.0	188	4.5	74.1	4.6
Mean		3381.0	11.99	13.9	0.0	216.3	4.9	75.4	3.2
LSD (.05)		574.0	1.94	0.6	0.3	29.2	1.2	2.5	0.8
C.V. (%)		17.2	16.36	4.2	747.2	13.7	25.4	3.3	27.0
F value		23.4**	19.12**	32.3**	2.3**	11.0**	10.4**	3.8**	15.9**

TEST R793. RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB RHIZOMANIA TEST), SALINAS, CA., 1993

(cont.)

Variety	Description	Acre Yield		Sucrose	Bolters	Beets/ 100'	Powdery Mildew	RJAP	CLS
		Sugar Lbs	Beets Tons	%	%	No.	Mean	%	Score

NOTES: Test R793 was planted in a field plot area with moderate to severe rhizomania about 8 kilometers from the location of tests 2293 and 2693. Unlike tests 2293 and 2693, the plots were hand harvested and weighed in the tare laboratory after being trimmed and washed.

Powdery mildew was not controlled in this test, but was not severe. Natural infection with Cercospora leaf spot (CLS) occurred late. Except for the most susceptible entries, CLS probably did not affect yield. Cyst nematodes were evident at harvest. The development of rhizomania symptoms was very good. This should be a good test of differentiate reaction and performance under rhizomania conditions.

In the USDA entries, a hybrid of R222R4 was grown rather than R222R4 per se. 2915, R078, R176-43,-89, R080, and 1867R are breeding lines under development at Salinas with the Rz (Holly) source of resistance.

Powdery mildew was scored on 10/06/93 on a scale of 0 to 9, where 9 is most severe. Cercospora leaf spot was scored on a scale of 0 to 9, where 9 would represent 90-100% defoliation of mature leaves.

To convert pounds sugar per acre to kg/ha, multiply by 1.12. For tons roots per acre to tonnes/h, multiply by 2.24. % S = pol. RJAP = raw juice apparent purity = (total soluble solids x 100)/%S. To convert beets/100 ft. to beets per acre, multiply by 233. To convert beets/100 ft. to beets per hectare, multiply by 575.

Test was grown under sprinkler irrigation. Irrigation frequency was regulated to promote severe rhizomania and prevent loss of highly diseased plants.

TEST 2293. NON-RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA
(IIRB RHIZOMANIA TEST), SALINAS, CA., 1993

16 entries x 8 replications, RCB (equalized)
1-row plots, 30 ft. (9.15M) long, 71 cm wide

Planted: April 20, 1993
Harvested: October 26-27, 1993

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew Mean	RJAP %
2293-1 IIRB entries									
C48 (KWS)	IIRB	13402	41.41	16.2	0.0	5.5	126	5.4	82.9
Stratos	IIRB	13393	40.48	16.6	0.0	8.0	120	3.5	81.4
Rizor	IIRB	13048	38.54	16.9	0.4	0.0	131	6.8	81.1
Monodoro	IIRB	12890	40.82	15.8	0.0	2.6	123	4.0	82.0
Roxane	IIRB	12843	40.70	15.8	0.0	4.7	113	5.3	81.3
Accord	IIRB	12387	39.46	15.7	0.0	8.5	126	3.9	82.3
R039C5	Inc. R939C5	12019	38.90	15.5	0.0	3.6	129	2.0	82.1
US H11	L113401	11406	38.54	14.8	0.0	0.6	135	7.8	81.3
2293-2 USDA entries									
6770	% S check	12871	36.52	17.6	0.0	6.9	138	4.4	83.3
R278H18	88-790-68H26 x R078	12719	39.31	16.2	0.0	1.4	148	6.4	81.5
R280H18	88-790-68H26 x R080	12185	37.89	16.1	0.0	2.2	148	6.6	82.1
Rhizoguard	L893301	12071	38.57	15.7	0.0	3.8	137	7.2	83.1
R280Y	RZM-BYV-ER R080	11613	37.59	15.4	0.0	0.0	141	5.1	82.0
R276Y	RZM-BYV-ER R076	11313	37.45	15.1	0.0	0.6	149	4.9	82.1
R232	RZM 1201-#(C)	11101	39.24	14.2	1.7	1.4	142	5.6	81.5
R222R4	RZM R122R3	10899	37.99	14.3	0.0	8.4	139	6.3	79.3
Mean		12260.0	38.96	15.7	0.1	3.6	134.0	5.6	81.8
LSD (.05)		1084.4	3.06	0.5	0.7	4.3	9.4	0.6	1.6
C.V. (%)		8.9	7.94	3.4	545.0	119.8	7.1	11.3	1.9
F value		4.4**	1.56NS	23.0**	3.0**	3.9**	10.2**	40.0**	2.9**

TEST 2293. NON-RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA (IIRB RHIZOMANIA TEST), SALINAS, CA., 1993

Variety	Description	Acre Yield		Sucrose	Bolters	Root Rot	Beets/ 100'	Powdery Mildew	RJAP
		Sugar Lbs	Beets Tons	%	%	%	No.	Mean	%

NOTES: Test was planted in field plot area about 500 meters from rhizomania plot area (see test 2693). The plot area for this non-rhizomania test had not been in sugarbeet for more than 20 years and rhizomania and nematodes were not evident at harvest.

The root rot in this test was caused by Erwinia carotovora betavasculorum and spread from adjacent powdery mildew-Erwinia root rot tests. Although powdery mildew control was attempted by two applications of Bayleton, infection pressure was very high and mildew occurred from about August 1, on. Powdery mildew was scored on a scale of 0 to 9 where 9 = 90 to 100% of the mature leaf area covered by mildew. Ratings were made on August 25 and September 1. This test was also near the virus yellows inoculated trials and after August 1, gradually many plants became naturally infected with virus yellows (BYV/BWYV). Earlier aphids were controlled with Metasystox-R and Lorsban.

In the IIRB set of entries, US H11 was added as a highly rhizomania susceptible check and C39R (R039C5) as a moderately resistant line with quantitative resistance. In the set of USDA entries, 6770 was used as a susceptible, high %S entry and "Rhizoguard" as a moderately resistant hybrid. R276Y, R280Y, R080, and R078 are breeding lines developed at Salinas with the Rz (Holly) source of resistance. 88-790-68H26 is a susceptible F_1CMS hybrid. R222R4 is the fourth cycle synthetic from a population that is 50% Beta maritima germplasm. R232 is an F_2 line between C37 sugarbeet and a rhizomania resistant, half-wild beet accession from Italy.

RJAP = raw juice apparent purity = (total soluble solids x 100)/%S. To convert beets/100 ft. to beets per acre, multiply by 233. To convert to beets per hectare, multiply by 575. To convert pounds/acre sugar yield to kg/h, multiply by 1.12. For tons roots/acre to tonnes/h, multiply by 2.24

See tests 2693 and R793 for results under rhizomania conditions.

TEST 2693. RHIZOMANIA YIELD TEST OF HYBRIDS WITH RESISTANCE TO RHIZOMANIA, (IIRB RHIZOMANIA TEST), SALINAS, CA., 1993

8 entries x 8 replications, RCB
2 row plots, 20 ft. (6.1M) long, 71 cm wide

Planted: May 17, 1993
Harvested: November 5, 1993

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Mean
Rizor	IIRB	7764	22.80	17.1	178	82.3	3.9
C48 (KWS)	IIRB	6657	21.53	15.5	178	83.8	4.8
Stratos	IIRB	6504	20.44	16.0	175	82.5	1.4
R039C5	Inc. R939C5	6045	19.30	15.7	181	82.9	1.2
Monodoro	IIRB	5452	18.48	14.8	173	82.6	2.6
Roxane	IIRB	4205	15.70	13.5	153	80.1	3.5
US H11	L113401	3772	15.30	12.3	205	79.9	6.3
Accord	IIRB	3187	12.73	12.6	159	78.0	2.4
Mean		5448.3	18.28	14.7	175.4	81.5	3.3
LSD (.05)		1051.3	3.27	0.5	10.2	2.3	1.4
C.V. (%)		19.2	17.81	3.7	5.8	2.8	42.3
F value		18.5**	8.97**	79.8**	19.1**	5.8**	12.7**

NOTES: US H11 is a highly rhizomania susceptible hybrid. R039C5 (=C39R) is a multigerm breeding line with quantitative resistance developed at Salinas. See test 2293-1 for same IIRB entries under non-rhizomania conditions. Also see test R793 for the IIRB entries tested under rhizomania conditions in a different location.

To convert pounds/acre sugar yield to kg/h, multiply by 1.12. For tons roots/acre to tonnes/h, multiply by 2.24. %S = pol. RJAP = raw juice apparent purity = (total soluble solids x 100)/%S. To convert beets/100 ft. to beets per acre, multiply by 233. To convert beets/100 ft. to beets per hectare, multiply by 575.

Powdery mildew was scored on 10/20 and 10/28, on a scale of 0 to 9, where 9 = 90-100% of the mature leaf area covered by mildew. Through most of the growing season, PM was controlled with Bayleton.

TEST R593. RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1993

16 entries x 8 replications, RCB (equalized)
1-row plots, 18 ft. long

Planted: June 10, 1993
Harvested: November 22, 1993

Variety	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/ 100' No.	Powdery Mildew 10/22	RJAP %
Checks								
Rizor	RZ3/1022	4038	12.74	15.8	0.0	278	7.4	76.1
Rhizosen	L493304 (9/11/92)	3341	11.77	14.2	0.0	215	4.6	78.1
US H11	L113401 (April 1993)	1461	6.14	12.0	0.0	193	4.4	70.8
R39 Synthetics								
R139C7	C7, RZM R039C6	4702	15.75	14.9	0.3	250	3.6	76.4
R039C5	C5, Inc. R939C5	4564	15.36	14.9	2.2	226	3.4	76.2
R239C8	C8, RZM R139C7	4528	14.88	15.2	0.0	272	2.9	78.1
Y439	CO, Inc. Y339	2625	8.75	15.0	0.6	238	3.4	76.6
R47 Synthetics								
R247C8	C8, RZM R147C7	3876	13.00	14.9	0.0	277	5.0	77.5
R147C7	C7, RZM R047C6	3871	13.13	14.8	0.0	265	5.1	77.9
Near-isogenic								
R276-89	RZM R176-89(C)	3980	13.52	14.7	0.0	242	2.5	76.8
Y231-89	Inc.Y131-89	2114	7.33	14.4	0.0	214	2.0	75.1
R22 Synthetics								
R122R3	C3, RZM R022R2	5662	20.42	13.9	0.4	235	7.9	76.5
R222R4	C4, RZM R122R3	5642	20.45	13.8	0.0	235	7.8	75.5
R280	RZM R080, (Y54Rz)	3904	12.90	15.1	0.0	274	4.5	77.3
R722	CO, Inc. F_2 (Y54 x B.m.)	2715	10.24	13.3	2.9	215	5.0	73.4
Y954	Inc. Y854	2168	7.81	13.9	0.0	211	3.1	75.4
Mean		3699.4	12.76	14.4	0.4	239.9	4.5	76.1
LSD (.05)		530.3	1.90	0.5	1.1	29.1	1.2	2.2
C.V. (%)		14.5	15.01	3.4	280.1	12.3	26.4	2.9
F value		41.8**	37.80**	28.7**	4.7**	6.8**	18.3**	5.8**

NOTES: See test R693.

TEST R693. RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1993

16 entries x 8 replications, RCB (equalized)
1-row plots, 18 ft. long

Planted: June 10, 1993
Harvested: November 19, 1993

Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Beets/ 100' No.	Powdery Mildew 10/22	RJAP %
R222R4	RZM R122R3	5846	21.59	13.6	0.0	227	8.4	77.2
R139C7	RZM R039C6 (C39R7)	4732	16.01	14.8	1.6	206	3.8	78.4
Z230	RZM Z120,2,4aa x 1913,1915	4275	14.62	14.6	0.0	225	5.4	78.6
R230	RZM R130	4104	14.78	13.9	0.0	245	4.5	78.3
R278	RZM R078, (C46/2Rz)	3961	12.97	15.3	0.0	248	3.9	79.8
2915	RZM 1913-#, 1915-#aa x A	3956	13.81	14.3	0.0	222	3.9	78.0
N203H15	1915aa x N103-1,N103	3413	14.29	11.9	0.0	208	8.0	75.2
N244	NR-RZM N144-1-#(C)	3393	14.60	11.6	0.0	206	6.6	77.0
2916	1905aa x 1913-#, 1915-#	3327	12.51	13.3	0.0	217	4.8	75.3
R232	RZM 1201-#(C)	3068	11.66	13.2	0.0	218	5.3	77.2
R279	RZM R079, (C37Rz)	2614	9.00	14.5	0.0	233	4.1	76.8
P201	PMR 1211,...,1216	2438	8.70	14.0	2.4	195	4.5	76.2
R228	RZM 1202-#(C)	2364	8.19	14.4	0.0	239	6.0	78.2
U86-46/2	Inc. C46/2 (86342)	1970	7.33	13.4	0.0	216	4.6	76.0
U86-37	Inc. C37 (86443)	1728	6.44	13.4	0.0	182	5.4	75.7
US H11	L113401 (April 1993)	1661	6.79	12.3	0.0	192	5.1	76.0
Mean		3303.1	12.08	13.6	0.2	217.4	5.3	77.1
LSD (.05)		572.2	2.02	0.7	1.0	27.5	1.1	2.8
C.V. (%)		17.5	16.87	5.4	400.3	12.8	21.2	3.7
F value		32.1**	32.57**	16.2**	3.9**	3.7**	12.5**	1.8NS

TEST R693. RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1993

(cont.)

Variety[1]	Description	Acre Yield		Sucrose	Bolters	Beets/ 100'	Powdery Mildew	RJAP
		Sugar Lbs	Beets Tons	%	%	No.	10/22	%

NOTES: Test was grown in Field C under moderate to severe rhizomania conditions. Powdery mildew was not controlled. Cyst nematodes were evident at harvest. Cercospora infection occurred late but caused little damage.

[1]R230 combines resistance from Rz and C28 (PI206407) in a C37 background. R228 = C28 backcrossed to C37. P201 = WB97 & 242 in a C37 background. R232 = Italian wild beet (weed beet) source crossed to C37. N244 = F_3BC_1 nematode resistant line. N203H15 = F_1BC_1 cyst nematode resistant hybrid between rhizomania resistant (Rz) popn-915 and C306, C603-1. R222R4 = 4th cycle selection synthetic from population that is 50% Beta maritima. 2916 = new composite population. Z230 = population that is 25% high sugar Polish germplasm.

TEST 2793-1,2,3,4. RHIZOMANIA EVALUATION OF LINES, SALINAS, CA., 1993[1,8]

64 entries x 8 replications, RCB
1-row plots, 20 ft. long

Planted: May 13, 1993
Harvested: November 8-9, 1993

Variety[2]	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %[7]	Beets/ 100' No.	Powdery Mildew Mean[6]	RJAP %
Test 2793-1.									
US H11	L113401	4633	18.17	12.8	0.0	0.0	181	4.0	78.6
Rhizosen	L493304 (9/11/92)	5060	17.21	14.7	0.0	0.4	181	4.4	82.5
Rizor	RZ3/1022	6851	20.77	16.5	0.0	0.0	185	2.3	81.1
Y439	CO, Inc. Y339	4943	16.84	14.7	0.0	0.0	196	0.3	81.6
R039C5	C5, Inc. R939C5	6274	20.49	15.4	0.0	0.7	176	0.1	82.9
R139C7	C7, RZM R039C6	5996	20.02	15.1	0.0	0.3	179	0.2	82.4
R239C8	C8, RZM R139C7	6216	20.56	15.1	0.0	0.3	196	0.1	83.0
R147C7	C7, RZM R047C6	5029	17.79	14.3	0.0	0.0	188	3.4	81.2
R247C8	C8, RZM R147C7	5378	18.73	14.4	0.0	0.0	186	3.4	81.1
R270Y	RZM-BYV-ER R070	6327	21.16	15.1	0.0	0.0	177	0.3	81.5
Y231-43	Inc. Y131-43	5412	19.38	13.9	0.0	0.0	195	0.8	81.4
R276-43	RZM R176-43(C)	5008	16.93	14.9	0.0	0.0	171	0.0	81.8
Y231-89	Inc.Y131-89	5012	17.83	13.9	0.0	0.0	183	1.6	78.9
R276-89	RZM R176-89(C)	5568	18.43	15.2	0.0	0.4	183	1.1	81.4
R276	RZM R076	5384	19.10	14.2	0.0	0.0	179	0.9	80.5
R276Y	RZM-BYV-ER R076	5521	19.18	14.4	0.0	0.0	178	2.1	82.1
Mean		5538.2	18.91	14.7	---	0.1	183.2	1.6	81.4
LSD (.05)		1056.7	3.46	0.6	---	0.6	21.2	1.5	2.7
C.V. (%)		19.3	18.46	4.4	---	457.2	11.7	95.2	3.3
F value		2.7**	1.30NS	12.3**	---	1.1NS	1.0NS	8.4**	1.7NS

[1] TEST 2793-4 RHIZOMANIA EVALUATION OF LINES, 1993. 64 entries x 8 replications, Incomplete blocks with 4 subsets each, 16 x 8 replications, RCB. Thus means across Tests 2791-1,-2,-3,-4 can be compared.

Mean	5533.5	19.21	14.5	0.1	0.1	178.9	1.7	80.7
LSD (.05)	1020.3	3.40	0.7	0.5	0.5	21.6	1.6	2.6
C.V. (%)	18.8	18.00	4.9	690.0	468.4	12.3	94.1	3.3
F value	7.4**	7.90**	13.1**	5.6**	1.7**	1.2NS	7.1**	2.9**

TEST 2793-1,2,3,4. RHIZOMANIA EVALUATION OF LINES, 1993 (SPENCE 2793)
(cont.)

Variety[3]	Description[3]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew Mean[6]	RJAP %
Test 2793-2.									
Y954	Inc. Y854	3905	15.14	13.2	0.0	0.4	182	0.9	78.4
R280	RZM R080	6077	19.91	15.3	0.0	0.0	192	1.3	81.7
R280Y	RZM-BYV-ER R080	6299	20.94	15.1	0.0	0.0	182	1.6	81.8
R722	Inc. F_2 (Y54 x B.m.)	6049	22.64	13.3	3.1	0.0	184	2.1	76.8
R122R3	RZM R022R2	8389	29.84	14.1	0.0	1.1	185	2.9	78.8
R222R4	RZM R122R3	8327	31.24	13.5	0.0	0.3	185	3.9	78.4
R280-1	Inc. R080-1	5178	16.91	15.5	0.0	0.0	179	1.0	80.8
R280-13	Inc. R080-13	5179	17.25	15.1	0.0	0.0	169	0.0	81.0
R280-28	Inc. R080-28	4546	14.96	15.3	0.0	0.0	183	1.1	81.0
R280-35	Inc. R080-35	4605	15.24	15.2	0.0	0.0	168	1.3	79.7
R280-45	Inc. R080-45	5837	18.77	15.6	0.0	0.0	186	0.0	82.3
R280-56	Inc. R080-56	4531	15.41	14.8	0.0	0.0	171	0.0	80.3
R280-79	Inc. R080-79	4676	15.25	15.4	0.0	0.0	181	0.4	81.2
R280-80	Inc. R080-80	5292	17.67	15.1	0.0	0.0	179	0.4	82.2
R139C7	RZM R039C6	5951	19.65	15.3	0.0	0.4	173	0.3	82.1
US H11	L113401	3853	15.31	12.6	0.0	0.0	184	4.2	77.3
Mean		5543.4	19.13	14.7	0.2	0.1	180.2	1.3	80.2
LSD (.05)		983.3	3.33	0.7	0.7	0.6	22.9	1.5	2.5
C.V. (%)		17.9	17.54	5.1	351.9	436.5	12.8	114.6	3.2
F value		14.5**	18.03**	14.1**	10.3**	1.9*	0.7NS	6.0**	4.0**

[2]R039C5,C7, and C8 are synthetics from cycles 5, 7, and 8 for mass selection for resistance to rhizomania. Y439 = CO = unselected source. Resistance was based upon visual symptoms in 4 mon. old plants. R231-#'s and R276-#'s are selections from C31/6.

[3]R122R3 and R222R4 are synthetics from cycles 2 and 3 for mass selection for resistance to rhizomania from R722. R722 = F_3 popn between Y54 sugarbeet and B.maritima accessions. R280 & R280Y are near-isolines of Y54 (C54). R280-#'s are increases of half-sib lines selected from line R80.

TEST 2793-1,2,3,4. RHIZOMANIA EVALUATION OF LINES, 1993 (SPENCE 2793)
(cont.)

Variety[4]	Description[4]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew Mean[6]	RJAP %
Test 2793-3.									
U86-37	Inc. C37 (86443)	3785	13.88	13.7	0.0	0.0	176	2.4	79.0
R279	RZM R079	4564	15.22	15.2	0.0	0.0	190	3.8	82.0
R279Y	RZM-BYV-ER R079	4009	13.61	14.7	0.0	0.0	174	4.1	79.9
R279R2	RZM 1204-#(C)	4461	15.57	14.4	0.0	0.0	181	4.9	79.5
R230	RZM R130	5683	20.12	14.2	0.0	0.0	193	1.4	80.7
R228	RZM 1202-#(C)	4790	16.91	14.2	0.0	0.0	185	4.9	80.0
P201	PMR 1211,...,1216	5262	19.52	13.4	0.7	0.3	182	1.4	76.7
R232	RZM 1201-#(C)	5712	20.55	13.9	0.7	0.0	168	2.3	82.2
R204	RZM R104	6818	26.59	12.9	0.0	0.0	166	1.3	81.1
U86-46/2	Inc. C46/2 (86342)	4758	16.88	14.1	0.0	0.0	186	1.0	80.0
R278	RZM R078	6663	21.46	15.6	0.0	0.0	185	0.9	82.7
R278Y	RZM-BYV-ER R078	6503	20.78	15.8	0.0	0.0	189	0.1	82.4
N244	NR-RZM N144-1-#(C)	5356	20.80	12.9	0.0	0.0	176	4.3	77.9
2914	RZM 1914	5472	18.51	14.8	0.0	0.0	173	0.4	82.8
90-WIV	RZM W4-89	6284	20.09	15.7	0.0	0.0	175	0.4	79.3
R222R4	RZM R122R3	8437	29.50	14.4	0.0	0.8	181	4.3	80.5
Mean		5534.8	19.37	14.4	0.1	0.1	179.9	2.4	80.4
LSD (.05)		980.6	3.33	0.7	0.7	0.4	18.3	1.7	2.8
C.V. (%)		17.9	17.32	5.0	803.9	623.9	10.3	74.7	3.5
F value		11.8**	12.95**	12.7**	0.9NS	1.8*	1.5NS	7.7**	3.1**

[4]R279, R279Y, and R279R2 are near-isolines of C37. R230 (Rz & PI07), R228 (PI07), P201 (WB97), R232 (R04) are lines with rhizomania resistance in a C37 background. R278 and R278Y are near-isolines of C46/2. N244 segregates for resistance to rhizomania (Rz) and cyst nematode. 2914 is S^f version of C39R. 90-WIV has rhizomania resistance from WB151. R222R4 see footnote 2.

[8]See Tests 793, 893 and 1493 for the performance of these lines under nondiseased and virus yellows conditions. See R593 and R693 for other rhizomania tests. See 493 for bolting evaluation and 2193 for Erwinia root rot evaluation.

TEST 2793-1,2,3,4. RHIZOMANIA EVALUATION OF LINES, 1993 (SPENCE 2793)
(cont.)

Variety[5]	Description[5]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew Mean[6]	RJAP %
Test 2793-4.									
P202	PMR 1217,...,1224	4319	16.63	13.0	0.0	0.0	169	1.1	78.5
R233	Inc. 1205(C)	5497	20.90	13.3	0.0	0.0	160	2.6	80.6
R229	Inc. 1206(C)	4569	17.20	13.6	0.0	0.0	166	1.9	80.9
5747	4747aa x A	4039	16.31	12.4	0.0	0.0	163	1.5	78.4
2911Y	RZM-BYV-ER 0911 (A,aa)	6033	21.21	14.4	0.0	0.0	181	0.6	80.9
2913	RZM 1913 (A,aa)	5976	19.87	15.2	0.0	0.0	182	1.1	82.0
2913Y	RZM-BYV-ER 0913 (A,aa)	5119	17.29	14.9	0.0	0.0	176	0.8	81.5
2915	RZM 1915-#(C) (A,aa)	4836	17.50	13.9	0.0	0.4	157	0.1	80.8
2915Y	RZM-BYV-ER 0915 (A,aa)	5529	19.04	14.5	0.0	0.0	173	0.2	81.9
2916	1905aa x 1913-#, 1915-#	5547	19.41	14.3	0.0	0.7	181	1.3	82.2
Z230	RZM Z120,2,4aa x 1913,1915	6591	21.06	15.7	0.0	0.0	171	1.7	82.7
Z220	RZM Z120,2,4 (A,aa)	5861	19.03	15.4	0.0	0.0	179	3.4	81.2
2915	RZM 1913-#, 1915-#aa x A	5894	20.30	14.6	0.0	0.0	176	0.3	80.2
N203H15	1915aa x N103-1,N103 (C603)	5966	22.73	13.1	0.0	1.0	166	5.5	77.4
R207	RZM R107	6463	21.59	15.0	0.0	0.0	182	3.8	79.9
R208	RZM R108	6038	20.44	14.8	0.0	0.0	174	1.1	82.1
Mean		5517.3	19.41	14.2	---	0.1	172.2	1.7	80.7
LSD (.05)		995.9	3.36	0.7	---	0.6	21.0	1.6	2.6
C.V. (%)		18.2	17.45	4.7	---	429.6	12.3	93.5	3.2
F value		4.4**	2.64**	16.5**	---	2.3**	1.2NS	7.0**	2.7**

[5]P202 is from a cross to WB242. R233 (Rz & PI07) and R229 (Rz) are backcross lines to 5747. 2911Y, 2913, 2913Y, 2915, 2915Y, & 2916 are MM,S^{f},A:aa populations with Rz. Z220 is 50% Polish %S germplasm. Z230 is 25% Polish %S germplasm. N203H15 is a hybrid with resistance to rhizomania and cyst nematode. R207 and R208 have rhizomania resistance from Rz and Italian gp.

[6]Powdery mildew scored 10/20/93 and 10/28/93 on a scale of 0 to 9 where 0 = no visable infection.

[7]Root rot due to Erwinia.

TEST 3093. RHIZOMANIA EVALUATION OF SELF-FERTILE, A:aa POPULATIONS, 1993[1]

24 entries x 4 replications, RCB
1-row plots, 20 ft. long

Planted: May 14, 1993
Harvested: November 16, 1993

Variety[2]	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew 10/18/93	RJAP %
R139C7	RZM R039C6	6681	21.53	15.6	163	1.5	82.2
US H11	L113401 (April 1993)	4015	16.07	12.6	173	5.3	77.3
F82-546H3	C562HO x C546	2495	9.35	13.5	165	4.3	77.4
2859R	RZM 1859R (A,aa)	4354	13.97	15.6	170	6.3	81.7
2859	RZM 1859 (A,aa)	5121	16.37	15.9	168	7.8	83.4
2859m	1859, 1859Rmmaa x A, (C859)	4895	16.01	15.4	174	6.0	81.3
2859M	1859,1859RMaa x A	5177	16.59	15.8	160	7.0	82.3
2865	RZM 1865-#(S_1) (A,aa)	5032	15.81	15.9	173	4.8	80.9
2865m	1865, 1865-#mmaa x A	4788	14.90	16.2	163	5.5	79.2
2865M	1865, 1865-#Maa x A	5551	17.43	16.0	184	6.8	80.3
2866	RZM 1866 (A,aa)	5050	16.94	15.0	166	4.8	78.8
2864	RZM 1864 (A,aa)	5630	18.36	15.6	171	5.5	82.6
2867	RZM 1867 (A,aa)	5013	16.84	15.0	155	3.5	80.5
2867m	1867, 1867Rmmaa x A	5432	18.72	14.5	180	5.0	81.0
2867M	1867, 1867RMaa x A	5591	18.53	15.2	173	4.3	81.9
2888m	Comp B mmaa x Comp A,B	6747	21.18	16.0	175	5.5	84.7
2888M	Comp B Maa x Comp A,B	6081	19.32	15.8	191	5.0	81.4
2889m	Comp C mmaax Comp A,B	6200	19.93	15.5	170	3.8	81.7
2889M	Comp C Maa x Comp A,B	6549	21.95	15.0	165	3.8	80.8

TEST 3093. RHIZOMANIA EVALUATION OF SELF-FERTILE, A:aa POPULATIONS, 1993

(cont.)

Variety[2]	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew Score	RJAP %
0790	8790-S_1(C)aa x A, (C790)	4399	15.75	14.0	180	2.0	80.5
2890	0790mmaa x 1890	5731	19.36	15.0	166	2.8	81.4
2891m	1890mmaa x A	5959	19.85	15.1	174	4.5	82.6
2891M	1890Maa x A	5184	17.38	15.1	188	4.5	80.3
92-790-15H39	89-762-17CMS x C790-15	4117	14.53	14.4	176	2.0	81.7
Mean		5241.4	17.36	15.2	171.7	4.7	81.1
LSD (.05)		1275.8	4.46	1.0	25.3	2.4	3.0
C.V. (%)		17.3	18.23	4.8	10.5	36.7	2.6
F value		4.5**	3.09**	5.6**	0.9NS	3.4**	2.6**

[1]Except for R139C7 and US H11 checks, these are S^f,A:aa populations that segregate for Rz and monogerm.

[2]546H3 is F_1CMS and seed bearing parent of US H11. 790-15H39 is F_1CMS rhizomania susceptible hybrid. Popn-859 has a high proportion of C562, C563 type germplasm. Popn-865 & -866 are similar to C310. Popns-864, -866, -867 have popn-767 type germplasm (popn-310 x C546). Popn-888 & -889 are composites. Popns-890 & -891 have popn-790 background.

TEST 3293. NEMATODE/RHIZOMANIA YIELD EVALUATION, SALINAS, CA., 1993

8 entries x 8 replications, RCB
1-row plots, 20 ft. long

Planted: May 14, 1993
Harvested: November 17, 1993

Variety[1]	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew 10/18/93	RJAP %
US H11	L113401 (April 1993)	4894	20.57	12.0	0.0	177	4.4	76.0
Rhizosen	L493304	7125	23.76	15.1	0.0	189	5.5	83.1
2J0181	Betaseed (4/20/93)	4535	19.29	11.7	0.0	159	1.0	72.7
2J5025	Betaseed (4/20/93)	3326	17.96	9.3	0.4	184	2.9	67.7
N203H15	1915aa x N103,N103-1	8196	32.18	12.9	0.0	175	6.4	77.8
N203H89	88-790-68CMS x N103,N103-1	5164	23.99	10.8	1.2	173	3.9	73.1
N244	NR-RZM N144-#-#(C)	5917	22.74	13.1	0.0	166	4.8	78.9
N152	NR-RZM 0204-2(C)	6428	25.32	12.8	0.0	169	4.8	80.2
Mean		5698.0	23.23	12.2	0.2	174.1	4.2	76.2
LSD (.05)		765.4	2.88	1.1	1.2	24.9	1.4	3.3
C.V. (%)		13.4	12.34	8.6	611.6	4.4	33.2	4.4
F value		33.0**	18.93**	21.6**	1.0NS	1.2NS	11.4**	17.3**

[1] 2J0181 & 2J5025 are rhizomania susceptible, cyst nematode resistant hybrids from Betaseed. N203H15 is resistant to both cyst nematode and rhizomania. N103, N103-1 = C603, C603-1 which are homozygous, cyst nematode resistant lines. N203H89 is rhizomania susceptible, cyst nematode resistant hybrid. N244 & N152 are populations that segregate for Rz and cyst nematode resistance.

Note: Test was grown under moderate to severe rhizomania conditions in a field plot area known to be infested with cyst nematode.

TEST 2893. RHIZOMANIA EVALUATION OF USDA HYBRIDS, SALINAS, CA., 1993

16 entries x 8 replications, RCB
1-row plots, 20 ft. long

Planted: May 14, 1993
Harvested: November 15, 1993

Variety[1]	Description[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew 10/18/93	RJAP %
US H11	L113401 (April 1993)	3628	13.75	13.1	0.0	197	4.6	78.9
Rizor	RZ3/1022	6881	20.53	16.8	0.0	178	1.8	79.4
Rhizoguard	893301	5112	16.60	15.4	0.0	175	5.3	81.2
HH 41	L412307	3323	13.02	12.8	0.0	184	4.1	77.9
R222RH20	87-309H3 x RZM R122R3	7438	23.74	15.7	0.0	194	5.5	79.8
2915H18	88-790-68H26 x 1913,1915	6687	20.53	16.3	0.0	187	2.4	81.0
R276H18	88-790-68H26 x R076	5732	17.49	16.4	0.0	192	2.0	82.3
R278H18	88-790-68H26 x R078	6054	18.32	16.5	0.0	179	1.6	81.9
R282H18	88-790-68H26 x R176-43,-89	5530	17.11	16.2	0.3	173	1.8	82.0
R280H18	88-790-68H26 x R080	6744	20.70	16.4	0.0	196	2.4	81.2
R280H58	1859Raa x R080	6384	19.77	16.1	0.0	164	4.4	80.6
R280H64	1864aa x R080	6531	20.66	15.8	0.0	164	3.6	80.0
R280H65	1865aa x R080	7553	22.69	16.6	0.3	196	5.4	81.4
R280H68	1867Raa x R080	6647	20.72	16.1	0.0	179	4.0	82.1
R280H90	0790aa x R080	5730	18.42	15.6	0.4	185	1.4	80.3
R280H93	1890aa x R080	6575	20.81	15.8	0.0	178	2.8	81.9
Mean		6034.3	19.05	15.7	0.1	182.7	3.3	80.7
LSD (.05)		982.2	3.00	0.6	0.4	20.2	1.8	1.9
C.V. (%)		16.4	15.86	4.1	646.5	11.2	53.9	2.3
F value		11.6**	7.53**	26.1**	0.9NS	2.2**	5.4**	3.7**

[1]309H3 = C562CMS x C309. 790-68H26 = C309CMS x C790-68. For popns-859, -864, -865, -867, -790, and -890, see Test 3093. For pollinator lines, see Test 2793.

TEST 2993. EVALUATION OF RHIZOMANIA RESISTANCE OF TEST CROSS HYBRIDS, SALINAS, CA., 1993[1]

32 entries x 4 replications, RCB
1-row plots, 20 ft. long

Planted: May 14, 1993
Harvested: November 15, 1993

Variety[2]	Description[2]	Acre Yield		Sucrose	Beets/ 100'	Powdery Mildew	RJAP
		Sugar Lbs	Beets Tons	%	No.	Score	%
2865H13	1913aa x 1865	7100	23.00	15.5	165	4.3	80.2
2865H15	1915aa x 1865	7077	22.06	16.1	194	3.8	79.3
2865H42-34	0909-34aa x 1865	7173	21.30	16.9	146	2.5	81.3
2865H43- 4	1911- 4aa x 1865	6722	21.78	15.5	149	4.5	78.9
2865H43-12	1911-12aa x 1865	6395	20.07	16.0	156	3.8	80.2
2865H43-14	1911-14aa x 1865	7191	22.58	16.0	176	2.8	80.0
2865H43-50	1911-50aa x 1865	6943	21.90	16.0	164	2.8	80.7
2865H45- 5	1913- 5aa x 1865	6984	23.09	15.3	175	3.8	79.8
2865H45-18	1913-18aa x 1865	7469	23.59	15.9	176	2.3	79.8
2865H45-22	1913-22aa x 1865	6580	20.81	15.9	168	2.8	79.2
2865H45-25	1913-25aa x 1865	7282	22.37	16.3	168	3.8	81.1
2865H46- 1	0911- 1aa x 1865	7071	21.95	16.1	189	3.5	81.1
2865H46-4(B)	0911-4(B)aa x 1865	7287	22.27	16.4	183	3.3	80.6
2865H46-24	0911-24aa x 1865	6028	19.75	15.4	168	3.0	76.1
2865H47- 6	0913- 6aa x 1865	6475	20.67	15.8	170	4.3	78.6
2865H47- 9	0913- 9aa x 1865	6067	19.26	15.7	173	5.5	80.5
2865H48- 1	0915- 1aa x 1865	6929	21.62	16.1	171	5.5	81.6
2865H48- 4	0915- 4aa x 1865	6300	19.95	15.8	191	4.8	80.1
2865H48- 6	0915- 6aa x 1865	6999	21.98	16.0	165	5.5	80.3
2865H48- 7	0915- 7aa x 1865	6765	20.79	16.3	165	4.5	81.7

TEST 2993. EVALUATION OF RHIZOMANIA RESISTANCE OF TEST CROSS HYBRIDS, SALINAS, CA., 1993

(cont.)

Variety[2]	Description[2]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Beets/ 100' No.	Powdery Mildew Score	RJAP %
2865H48-16	0915-16aa x 1865	6210	19.85	15.7	168	4.0	79.7
2865H48-22	0915-22aa x 1865	6343	20.07	15.8	166	2.8	81.1
2865H48-23	0915-23aa x 1865	6927	22.58	15.3	181	3.5	79.2
2865H48-24	0915-24aa x 1865	7565	25.09	15.1	169	4.5	78.8
2865H48-27	0915-27aa x 1865	6950	22.27	15.6	180	4.3	80.0
2865H48-34	0915-34aa x 1865	7216	22.44	16.1	176	5.0	81.8
2865H48-46	0915-46aa x 1865	6378	20.27	15.8	164	5.3	81.8
2915H58	1859Raa x 1913,1915	6640	21.11	15.7	161	4.3	79.9
2915H65	1865aa x 1913,1915	6918	21.73	15.9	184	4.3	79.7
2915H68	1867aa x 1913,1915	6929	22.58	15.4	179	2.3	80.2
2915H90	0790aa x 1913,1915	7244	24.14	15.1	185	2.5	79.8
R280H65	1865aa x R080	7690	23.74	16.2	186	5.3	80.8
Mean		6870.2	21.77	15.8	172.1	3.9	80.1
LSD (.05)		1491.2	4.75	0.7	26.6	2.9	2.3
C.V. (%)		15.5	15.54	3.2	11.0	53.1	2.1
F value		0.7NS	0.67NS	2.4**	1.4NS	1.0NS	1.9*

[1]Test 2993 set astraddle of Test 2893 (2 reps on each side); therefore, see checks and entries for Test 2893 for close approximation of yield.

[2]1865 = popn-865 = monogerm, S^f, A:aa population that segregates for Rz. Hybrids 2865H13 & 2865H15 vs. 2915H65 would be near reciprocal population hybrids. Lines 909-34, 911-#'s, 913-#'s, & 915-#'s are progeny selections from MM,S^f,A:aa,Rz. Populations-909,-911,-913, & -915. Selection was based upon performance under rhizomania and/or other criteria (virus yellows, Erwinia, powdery mildew, bolting, %S...). 0909-34, 1911-4, -12, -14, & -50 were released in 1983 as C909-34, C911-4, -12, -14, & -50.

TEST 2493. WESTERN SUGAR AND JOINT GROWER HOLLY RHIZOMANIA TEST, SALINAS, CA., 1993

24 entries x 6 replications, RCB
1-row plots, 20 ft. long

Planted: May 17, 1993
Harvested: November 4, 1993

Variety[1]	Description		Acre Yield				Root	Beets/	Powdery	
	WS[3]	JG-H[4]	Sugar Lbs	Beets Tons	Sucrose %	Bolters %	Rot %	100' No.	Mildew[2] Mean	RJAP %
2J0152	x		6996	21.10	16.6	0.0	0.0	173	0.4	83.5
Beta 4581	x	x	6621	21.84	15.2	0.0	0.0	189	2.1	83.6
Rhizosen	x	x	5755	18.22	15.8	0.0	0.0	188	5.1	83.3
SX 0212	x		5643	17.38	16.2	0.0	0.0	139	4.3	83.6
SS-596R	x		5600	18.46	15.2	0.0	0.0	171	2.9	81.9
Maribo 9372	x		5580	17.75	15.8	0.0	0.3	194	2.3	80.9
SS 595R	x		5456	17.64	15.5	0.0	0.0	182	2.8	82.4
Rhizosen Plus	x	x	5105	16.22	15.7	0.0	0.0	175	5.4	81.2
Rhizoguard	x	x	5028	16.26	15.5	0.0	0.0	163	5.9	81.7
2J0179	x	x	4988	16.02	15.5	0.0	0.0	142	2.9	81.3
SS-781R	x		4840	15.63	15.5	0.0	0.0	174	3.6	82.8
Rhizosen CT	x	x	4607	15.60	14.9	0.4	0.0	178	4.0	84.0
Monohikari	x		4517	15.37	14.7	0.0	0.0	185	3.8	83.1
Rhizoguard CT	x	x	4283	15.02	14.4	0.0	0.0	181	3.1	82.0
ACH 9250332	x	x	3873	14.45	13.4	0.0	0.0	172	3.3	79.3
USDA Entries and Checks										
R222R4	RZM R122R3		8430	28.90	14.6	1.2	1.6	180	3.4	80.0
N203H15	1915aa x N103,N103-1		6843	25.43	13.6	0.0	0.6	187	5.7	79.9
Rizor	RZ3/1022 (1993)		6237	18.89	16.5	0.0	0.0	189	1.6	80.8
R280H18	88-790-68H26 x R080		6000	19.22	15.7	0.0	0.0	187	3.5	81.3
R278H18	88-790-68H26 x R078		5971	19.03	15.8	0.0	0.0	191	2.1	82.7
R039C5	Inc. R939C5, (C39R5)		5534	17.62	15.7	0.0	0.0	174	0.6	82.1
R232	RZM 1201-#(C)		5519	19.30	14.3	0.4	0.0	171	3.8	81.4
R276Y	RZM-BYV-ER R076		5003	16.51	15.2	0.0	0.0	164	1.5	82.2
US H11	L113401 (4/93)		3604	13.53	13.3	0.0	0.0	166	3.1	81.1

TEST 2493. WESTERN SUGAR AND JOINT GROWER HOLLY RHIZOMANIA TEST, SALINAS, CA., 1993
(cont.)

Variety[1]	Description WS[3]	Description JG-H[4]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Powdery Mildew[2] Mean	RJAP %
Mean			5927.1	19.66	15.1	0.1	0.1	177.0	3.7	81.9
LSD (.05)			1015.0	3.02	0.8	0.5	0.4	20.6	1.7	2.8
C.V. (%)			15.0	13.43	4.7	698.9	647.0	10.2	41.5	3.0
F value			9.9**	12.03**	10.1**	0.9NS	1.8*	3.7**	6.2**	1.6NS

Notes: Test was in a field with severe rhizomania but in addition, other soil-borne problems apparently occured. Following emergence, many seedlings appeared to be infected by Aphanomyces. Thinning was delayed and best plants were saved when thinned. However, an Aphanomyces like disorder continued to show in some areas of the field. Roots at harvest were often sprangled. Cyst nematodes were evident at harvest and may have reduced yields. Cyst nematode infestation may account for the better than expected performance of nematode resistant hybrid N203H15. The wide dispersion in yield is thought to be primarily caused by differential reaction to rhizomania, but many other factors appeared to significantly influence yield in this test also.

Foliar diseases and other viruses did not appear to be important in this test.

% sugar is higher than usual for rhizomania infected tests. Sugar concentration and appearance of plants at harvest suggested that a nitrogen deficiency occurred. A total of more than 240 units of nitrogen was applied preplant and in two sidedress applications. Frequent sprinkler irrigations (2x per week) to promote severe rhizomania and keep infected plants alive may have moved the nitrogen out of the root zone of the disease impaired plants growing in this sandy loam soil.

One entry gave very encouraging results. Despite all the soil-borne problems, for a five-month crop, R222R4 would appear to have a normal, nondiseased performance. This has been observed in other tests at Salinas and Imperial Valley for this line that was derived from composite crosses between sugarbeet and many Beta maritima accessions. It is yet unknown whether this is high resistance to rhizomania and/or resistance to rhizomania and other soil-borne disease (Aphanomyces, cyst nematodes, etc.).

TEST 2493. WESTERN SUGAR AND JOINT GROWER HOLLY RHIZOMANIA TEST, SALINAS, CA., 1993
(cont.)

Because of the complexity of root problems, it did not appear that scoring individual plants or plots for rhizomania symptoms would be meaninful. Gross sugar yield has appeared at Salinas to be the most useful criterion for evaluating a variety's reaction to rhizomania. Entries that are significantly higher yielding than the susceptible check (US H11) should be considered to have partial resistance or tolerance to rhizomania.

[1]US H11 is a susceptible check. This version, however, appeared to be more tolerant to rhizomania than previous versions. Rizor is a commercial hybrid with resistance to rhizomania used in Europe and Japan. N203H15 is a cyst nematode resistant hybrid between rhizomania resistant (Rz) population-915 and homozygous, nematode resistant lines C603 and C603-1. R222R4 is the 4th cycle selection for resistance to rhizomania from a population that is half Beta maritima. R232 is an F_2 line from a rhizomania resistant, partially wild beet accession from Italy crossed to C37 sugarbeet. R276Y is the Rz near-isogenic line of C31/6. R078 and R080 are the Rz near-isogenic lines of C46/2 and C54. 88-790-68H26 is a rhizomania susceptible, monogerm, F_1CMS hybrid.

[2]Powdery mildew was scored twice on 10/20/93 and 10/28/93. Test was treated with 16 ounces a.i./ acre of Bayleton on August 4, 1993 and remained free of mildew until late in September. Mildew probably had little affect on yield. Powdery mildew scored from 0 to 9 where 9 = 90-100% of mature leaf area covered with mildew. Powdery mildew reaction is thought to be influenced by severity of rhizomania; therefore, partially rhizomania resistant varieties may appear relatively more susceptible to powdery mildew than the rhizomania susceptible entries.

[3]WS: Entries submitted by Western Sugar Committee.

[4]JG-H: Entries submitted by Joint Grower-Holly Committee.

TEST 2393. CBGA/BSDF CODED RHIZOMANIA VARIETY TRIAL, SALINAS, CA., 1993

58 entries x 5 replications, RCB
1-row plots, 20 ft. long

Planted: May 17, 1993
Harvested: November 1-3, 1993

Code No.	Variety[1]	Company	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew[2] Mean	RJAP %
CBGA Checks									
RS-18	Rima	Check	7148	21.30	16.7	0.0	167	2.5	84.3
-34	Rhizoguard	Check	6130	20.47	15.0	0.0	179	6.3	81.8
- 2	C39R	Check	5540	17.80	15.6	0.0	148	0.2	82.8
-47	US H11	Check	3427	13.09	13.2	0.0	184	3.2	79.3
CBGA Coded Entries									
RS-10	2BG6241	Betaseed	7294	23.27	15.6	0.5	182	0.8	82.7
- 5	HM 3041	Hill-MH	7134	23.69	15.0	0.0	203	6.2	81.7
- 3	HM 3042	Hill-MH	7078	23.49	15.1	0.0	212	2.6	81.9
- 9	2BG6247	Betaseed	6954	23.49	14.8	0.0	162	0.2	81.1
-51	93HX29	Holly	6893	21.50	16.0	0.0	185	2.9	81.3
-49	93HX15	Holly	6809	22.34	15.2	0.0	190	5.8	83.3
-23	93HX27	Holly	6706	21.17	15.9	0.0	193	4.5	82.4
-16	93HX13	Holly	6580	21.41	15.4	0.0	169	7.7	81.6
-30	SS-781R	Spreckels	6580	21.50	15.3	0.0	203	4.5	82.0
-26	SS-289R	Spreckels	6519	20.92	15.5	0.0	190	6.5	81.5
-14	2BG6243	Betaseed	6504	21.13	15.3	0.0	195	0.5	81.5
-32	Rhizosen	Holly	6479	20.19	16.0	0.0	191	7.3	82.6
-25	SS-334R	Spreckels	6387	20.86	15.4	0.0	175	6.3	81.5
-39	93HX24	Holly	6309	22.09	14.4	0.0	172	5.1	82.7
-43	93HX28	Holly	6301	19.40	16.2	0.0	182	1.0	82.0
- 7	2BG6237	Betaseed	6235	21.28	14.7	0.0	179	0.1	81.2
-27	90C 64-05	Holly	6233	20.50	15.2	0.0	168	6.3	81.9
-22	93HX06	Holly	6218	19.13	16.2	0.0	194	3.2	83.1
-13	Rhizosen CT	Holly	6190	20.38	15.2	0.0	192	5.2	80.9
-36	90C 68-03	Holly	5924	19.99	14.9	0.0	183	5.3	81.8

TEST 2393. CBGA/BSDF CODED RHIZOMANIA VARIETY TRIAL, SALINAS, CA., 1993
(cont.)

Code No.	Variety[1]	Company	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew[2] Mean	RJAP %
CBGA Coded Entries (cont.)									
RS-29	SS-780R	Spreckels	5895	20.16	14.6	0.6	168	4.5	82.4
-28	93HX07	Holly	5884	19.15	15.4	0.0	171	5.5	82.2
- 4	2BG6245	Betaseed	5878	18.97	15.6	0.7	179	1.3	83.1
-19	SS-NB2R	Spreckels	5820	19.15	15.2	0.6	182	4.9	82.5
-24	2BG6249	Betaseed	5799	18.80	15.4	0.0	91	0.9	82.3
-31	93HX14	Holly	5795	18.90	15.3	0.0	188	6.6	81.4
-37	2BG6239	Betaseed	5717	19.32	15.0	0.0	189	0.3	81.9
-40	SS-293R	Spreckels	5703	19.83	14.4	0.0	131	2.5	79.8
-50	HM 3027	Hill-MH	5570	18.16	15.4	0.7	165	2.3	82.0
-44	Beta 4581	Betaseed	5523	18.77	14.6	0.0	153	3.3	80.7
-35	93HX25	Holly	5385	18.38	14.7	0.6	164	4.3	81.6
-38	Rhizosen Plus	Holly	5362	18.02	14.8	0.0	190	5.9	80.8
-33	93HX05	Holly	5306	17.23	15.4	0.0	165	5.0	83.3
- 8	SS-287R	Spreckels	5296	18.28	14.3	0.0	194	5.1	80.3
-41	SS-595R	Spreckels	5238	17.44	15.0	0.0	169	4.9	81.9
-42	SS-596R	Spreckels	5230	17.72	14.8	0.0	173	5.6	81.7
-45	Rhizoguard	Holly	5177	17.22	15.0	0.0	150	5.2	81.1
-17	90C 68-04	Holly	5160	16.85	15.3	0.0	144	3.5	81.5
- 1	90-88C11-09	Holly	5154	16.83	15.4	0.0	171	5.7	81.6
-12	SS-593R	Spreckels	5041	17.28	14.5	0.7	148	3.8	80.2
-11	90-1459-0188	Holly	5032	16.69	15.1	0.0	157	3.9	81.9
-46	HM 3026	Hill-MH	4962	16.98	14.7	0.0	164	1.7	82.7
-15	93HX26	Holly	4469	16.12	13.9	0.0	165	4.9	81.4
-48	90-87C34-06	Holly	4400	15.72	14.1	0.0	156	3.1	82.1
-20	93HX11	Holly	4289	15.87	13.4	0.0	159	3.4	81.5
-21	0BG6333	Betaseed	4247	15.12	13.9	0.0	166	2.3	77.0
- 6	1BG6131	Betaseed	3888	15.05	12.8	0.0	170	2.1	78.5

TEST 2393. CBGA/BSDF CODED RHIZOMANIA VARIETY TRIAL, SALINAS, CA., 1993
(cont.)

Code No.	Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew[2] Mean	RJAP %
USDA entries and Checks									
	R222R4H20	87-309H3 x RZM R122R3	7688	25.12	15.3	0.0	198	5.8	79.6
	Rizor	RZ3/1022 (1993)	7355	22.51	16.4	0.0	191	0.3	80.9
	R139C7	RZM R039C6, (C39R7)	7044	23.19	15.2	0.0	175	0.5	82.8
	R280H20	87-309H3 x R080	6247	20.13	15.6	0.0	195	5.1	80.8
	R276Y	RZM-BYV-ER R076	6230	21.59	14.5	0.0	181	2.1	82.4
	US H11	L113401 (April 1993)	4930	18.91	13.0	0.0	165	4.4	79.7
	6770	KW 6770 (1993)	4545	16.01	14.1	0.0	150	2.8	80.5
Mean			5905.9	19.51	15.1	0.1	172.7	3.5	81.7
LSD (.05)			1146.6	3.65	0.7	0.4	23.4	1.6	2.0
C.V. (%)			19.7	19.01	4.7	675.0	13.8	45.9	2.5
F value			3.4**	2.47**	6.5**	0.9NS	3.6**	9.1**	2.0**

TEST 2393. BETASEED ENTRIES RHIZOMANIA VARIETY TRIAL, SALINAS, CA., 1993

17 entries x 5 replications, RCB
1-row plots, 20 ft. long

Planted: May 17, 1993
Harvested: November 1-3, 1993

Code No.	Variety[1]	Description	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Root Rot %	Beets/ 100' No.	Powdery Mildew[2] Mean	RJAP %
CBGA Checks									
RS-18	Rima	Check	7148	21.30	16.7	0.0	167	2.5	84.3
-34	Rhizoguard	Check	6130	20.47	15.0	0.0	179	6.3	81.8
- 2	C39R	Check	5540	17.80	15.6	0.0	148	0.2	82.8
-47	US H11	Check	3427	13.09	13.2	0.0	184	3.2	79.3
BSDF Entries									
	2J0152	Betaseed (1993)	7783	23.67	16.3	0.0	172	1.0	82.6
	1N7238	Betaseed (1993)	7300	22.10	16.5	0.0	143	1.4	84.0
	2J5088	Betaseed (1993)	7035	22.26	15.8	0.0	177	0.0	85.1
	1J7002	Betaseed (1993)	6840	22.42	15.2	0.0	190	0.8	82.6
	2J0156	Betaseed (1993)	5153	15.84	16.1	0.0	164	0.8	82.4
	2J0179	Betaseed (1993)	5043	16.18	15.5	0.0	130	1.4	81.5
USDA entries and Checks									
	R222R4H20	87-309H3 x RZM R122R3	7688	25.12	15.3	0.0	198	5.8	79.6
	Rizor	RZ3/1022 (1993)	7355	22.51	16.4	0.0	191	0.3	80.9
	R139C7	RZM R039C6, (C39R7)	7044	23.19	15.2	0.0	175	0.5	82.8
	R280H20	87-309H3 x R080	6247	20.13	15.6	0.0	195	5.1	80.8
	R276Y	RZM-BYV-ER R076	6230	21.59	14.5	0.0	181	2.1	82.4
	US H11	L113401 (April 1993)	4930	18.91	13.0	0.0	165	4.4	79.7
	6770	KW 6770 (1993)	4545	16.01	14.1	0.0	150	2.8	80.5
Mean			5905.9	19.51	15.1	0.1	172.7	3.5	81.7
LSD (.05)			1146.6	3.65	0.7	0.4	23.4	1.6	2.0
C.V. (%)			19.7	19.01	4.7	675.0	13.8	45.9	2.5
F value			3.4**	2.47**	6.5**	0.9NS	3.6**	9.1**	2.0**

TEST 2393. CBGA/BSDF CODED RHIZOMANIA VARIETY TRIAL, SALINAS, CA., 1993

(cont.)

NOTES: Test was designed as a 64 entry x 8 replication test. Entries 1 thru 51 were for the coded rhizomania test. Entries 52 thru 57 were from a private seed company. Entries 58 thru 64 were entries and checks included by the USDA. Because of cultural and disease problems within replications 2,3, and 7, these were deleted from the ANOVA, and final results are presented as a five replication test.

A gradient in soil fertility and disease expression occurred from the top to the bottom (direction of replication) of the field. A more serious gradient also occurred from the left to the right side of the test. Rhizomania and other soil-borne problems were moderate to severe. In addition to rhizomania, what appeared to be Aphanomyces caused seedling loss, sprangling, and stunted growth. Cyst nematodes were observed at harvest. Other foliar and virus diseases did not appear to be significant.

[1]USDA entries and checks: US H11 accessed in April 1993; it appeared in this and other rhizomania tests to be different (more tolerant) than US H11 previously used. 6770 is a high % sugar, susceptible check used in most 1993 tests at Salinas. Rizor was obtained from SES in 1993. R076 and R080 are Rz near-isogenic lines of C31/6 and C54. R222R4H20 is a hybrid between a susceptible F_1CMS hybrid and pollinator derived from a sugarbeet x Beta maritima population; it is 50% B.maritima.

[2]Powdery mildew was controlled until late September with 16 ounces a.i./acre Bayleton. It was scored on 10/18/93 and 10/28/93 on a scale of 0 to 9 where 9 is highly susceptible.

TEST 3193. RHIZOMANIA EVALUATION/SELECTION OF S_1 MONOGERM LINES, SALINAS, CA., 1993

112 entries x 2 replications
1-row plots, 20 ft. long

Planted: May 14, 1993
Harvested: November 16-17, 1993

Variety[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Rz[2] rating	Vigor[3] rating	Color[4] rating	Unif[5]	Root Rot %	Beets/ 100' No.	Powdery Mildew 10/18/93	RJAP %
Lines from popn-859											
2859Am(Sp)- 1	4430	14.26	15.5	1	3	G	2	0.0	160	0.5	82.1
- 2	5288	16.59	16.0	2	3	G	2	0.0	160	2.0	82.2
- 3	2970	10.29	14.5	2	2	V	3	0.0	155	6.0	76.5
- 4	2327	8.40	13.5	3	4	Y	3	3.2	160	4.0	73.2
- 5	3030	10.16	14.9	1	3	G	2	0.0	160	5.5	77.8
- 6	3387	11.13	15.2	2	3	V	3	0.0	175	6.5	77.8
- 7	4572	14.24	16.0	2	4	V	4	0.0	165	4.5	84.3
- 8	4325	13.44	16.1	2	4	V	4	0.0	175	0.0	80.3
- 9	5285	16.65	15.9	2	2	G	3	0.0	140	5.5	81.9
-10	5048	16.17	15.6	2	2	G	3	0.0	148	5.0	82.1
-11	3450	11.13	15.5	2	3	G	2	0.0	150	0.5	79.5
-12	3484	11.83	14.8	2	3	V	4	0.0	150	0.5	79.5
-13	1062	3.51	15.1	2	5	Y	4	0.0	58	1.5	79.3
-14	4785	14.54	16.5	2	4	V	3	0.0	160	2.0	80.1
-15	3475	12.39	14.0	3	4	V	3	0.0	180	0.0	81.6
-16	3907	12.60	15.5	2	3	V	3	0.0	153	0.0	81.2
-17	2647	8.40	15.8	2	4	G	3	0.0	163	2.0	81.2
-18	2257	7.56	14.9	2	4	V	5	0.0	155	2.0	80.0
-19	2417	7.98	15.1	2	3	G	2	0.0	160	2.0	79.1
-20	2392	7.35	16.0	2	4	V	4	0.0	168	2.0	79.1
-21	4389	13.01	16.9	2	3	V	5	0.0	110	4.0	83.9
-22	3000	10.08	14.9	2	4	V	3	0.0	168	0.0	80.5
-23	3801	12.18	15.6	1	2	G	2	0.0	120	4.5	81.7
-24	1329	4.83	13.6	2	4	V	4	0.0	163	2.0	78.1

TEST 3193. RHIZOMANIA EVALUATION/SELECTION OF S_1 MONOGERM LINES, SALINAS, CA., 1993
(cont.)

Variety[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Rz[2] rating	Vigor[3] rating	Color[4] rating	Unif[5]	Root Rot %	Beets/ 100' No.	Powdery Mildew 10/18/93	RJAP %
Lines from popn-859 (cont.)											
2859Am(Sp)-25	2734	9.66	14.0	2	3	V	3	0.0	145	7.0	77.7
-26	1294	5.60	11.3	3	5	Y	4	0.0	165	3.0	68.1
-27	3794	12.60	15.1	2	3	V	4	0.0	103	6.5	78.8
-28	4063	12.81	15.9	2	4	Y	2	0.0	163	4.5	80.1
-29	2721	9.20	14.7	3	4	Y	2	0.0	155	1.5	83.3
-30	2987	9.45	15.8	2	4	V	5	0.0	140	2.0	79.0
Checks											
F82-546	1311	4.83	13.4	3	4	V	2	0.0	158	0.5	77.3
87-309H3	2871	11.34	12.7	3	3	V	3	0.0	170	1.5	75.3
TEST 3193-2.											
Lines from popn-865											
2865mA(Sp)- 1	3750	12.93	14.5	2	2	G	3	0.0	188	4.0	76.3
- 2	1591	5.25	15.1	2	3	G	2	0.0	180	4.5	73.6
- 3	4590	14.28	16.0	2	3	G	2	0.0	213	4.5	79.2
- 4	6720	20.37	16.5	1	1	G	1	0.0	198	3.5	83.3
- 5	2451	7.77	15.8	1	2	G	2	0.0	180	2.0	78.8
- 6	3945	12.60	15.6	2	2	G	2	1.4	185	4.5	82.1
- 7	3920	13.02	15.1	2	3	G	2	0.0	195	2.0	74.2
- 8	3283	10.87	15.1	2	3	G	3	0.0	110	4.0	76.5
- 9	3032	10.58	14.4	2	3	V	2	0.0	180	6.5	76.3
-10	3836	12.60	15.2	2	4	V	3	0.0	175	5.0	72.9
-11	4051	12.93	15.6	2	3	V	3	0.0	170	3.5	77.7
-12	3202	10.17	15.7	2	4	V	3	1.4	158	1.5	74.6

TEST 3193. RHIZOMANIA EVALUATION/SELECTION OF S_1 MONOGERM LINES, SALINAS, CA., 1993 (cont.)

Variety[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Rz[2] rating	Vigor[3] rating	Color[4] rating	Unif[5]	Root Rot %	Beets/ 100' No.	Powdery Mildew 10/18/93	RJAP %
TEST 3193-2. (cont.)											
Lines from popn-865 (cont.)											
2865mA(Sp)-13	3908	12.81	15.3	2	2	V	3	0.0	190	2.0	79.0
-14	5762	18.06	15.9	1	1	G	1	0.0	118	5.5	78.0
-15	5087	16.80	15.3	1	3	V	2	0.0	170	2.5	78.2
-16	3522	11.67	15.1	3	3	Y	2	0.0	185	7.0	80.3
-17	4606	14.81	15.6	3	4	Y	3	0.0	150	7.5	76.8
-18	5030	16.09	15.8	2	2	V	4	0.0	170	4.5	80.9
-19	1851	7.50	12.6	2	3	V	4	1.7	105	4.0	72.2
-20	2556	8.61	15.0	2	4	V	4	0.0	143	2.0	75.9
-21	5089	16.38	15.5	1	2	V	2	0.0	135	0.0	79.3
-22	3711	12.93	14.4	1	4	G	1	0.0	188	1.0	73.8
-23	3547	12.04	14.8	2	3	V	2	0.0	183	6.0	79.5
-24	4908	15.54	15.9	3	4	Y	3	0.0	190	3.0	79.5
Checks											
87-309H3	2974	11.13	13.6	3	3	Y	4	0.0	178	3.5	80.5
F82-546H3	2185	8.40	13.6	3	4	Y	3	0.0	175	2.5	79.3
TEST 3193-3.											
Lines from popn-867											
2867Am(Sp)- 1	4327	13.71	16.0	2	3	G	4	0.0	153	1.5	79.7
- 2	3495	12.39	14.3	2	3	G	3	0.0	148	2.0	77.2
- 3	4167	13.77	15.1	2	3	G	3	0.0	178	3.5	80.6
- 4	3571	12.60	14.5	2	4	G	3	0.0	160	2.0	79.9
- 5	4795	15.75	15.4	3	4	V	3	0.0	178	2.5	81.3
- 6	6496	22.27	14.8	1	1	G	3	0.0	173	4.5	82.5
- 7	3794	12.82	15.0	2	3	V	3	0.0	125	3.5	80.8
- 8	2598	9.45	14.0	2	3	V	3	0.0	165	1.5	79.9

TEST 3193. RHIZOMANIA EVALUATION/SELECTION OF S_1 MONOGERM LINES, SALINAS, CA., 1993 (cont.)

Variety[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Rz[2] rating	Vigor[3] rating	Color[4]	Unif[5]	Root Rot %	Beets/ 100' No.	Powdery Mildew 10/18/93	RJAP %
TEST 3193-3. (cont.) Lines from popn-867 (cont.)											
Checks											
F92-790-15H39	3756	13.44	14.0	2	3	Y	3	0.0	178	1.5	80.0
F92-790-15CMS	3392	12.81	13.3	2	2	Y	2	0.0	188	0.5	80.8
TEST 3193-4. Lines from popn-891											
2891Am(Sp)- 1	3299	11.76	14.1	3	3	V	2	0.0	180	5.5	80.2
- 2	5358	18.27	14.6	3	3	V	2	0.0	183	2.0	81.6
- 3	5287	18.69	14.9	3	4	Y	2	0.0	160	2.0	78.0
- 4	5074	15.96	16.5	2	4	G	3	0.0	185	0.5	81.6
- 5	3726	13.02	14.5	2	4	V	4	0.0	188	0.5	80.3
- 6	2294	8.40	13.9	3	4	Y	4	0.0	165	1.5	81.3
- 7	5287	18.27	14.9	2	3	G	2	0.0	180	0.5	77.3
- 8	4683	15.37	15.5	3	3	Y	2	0.0	178	1.5	81.4
- 9	5024	16.80	15.1	2	3	V	3	0.0	195	2.5	81.6
-10	5145	16.38	15.9	2	3	V	3	0.0	163	3.5	81.2
-11	5019	19.11	13.8	2	4	G	3	0.0	150	0.5	78.0
-12	4344	16.38	13.4	2	3	Y	4	0.0	128	2.0	77.7
-13	5362	19.11	14.1	2	3	G	2	0.0	153	0.0	80.6
-14	2304	10.08	11.9	3	4	Y	2	0.0	200	4.0	73.9
-15	4394	14.71	15.1	2	4	V	3	0.0	158	3.0	78.9
-16	7872	23.95	16.3	2	2	V	3	0.0	180	5.5	89.5
-17	4416	15.39	14.6	3	4	Y	2	0.0	153	2.5	85.9
-18	4032	14.12	14.5	1	4	G	1	0.0	195	2.5	79.0

TEST 3193. RHIZOMANIA EVALUATION/SELECTION OF S_1 MONOGERM LINES, SALINAS, CA., 1993
(cont.)

Variety[1]	Acre Yield Sugar Lbs	Acre Yield Beets Tons	Sucrose %	Rz[2] rating	Vigor[3] rating	Color[4] rating	Unif[5]	Root Rot %	Beets/ 100' No.	Powdery Mildew 10/18/93	RJAP %
TEST 3193-4. (cont.)											
Lines from popn-891 (cont.)											
2891Am(Sp)-19	3970	13.23	15.0	2	3	Y	1	0.0	188	4.5	82.0
-20	4556	15.12	15.1	2	3	G	3	0.0	165	2.5	81.8
-21	4794	16.94	14.4	2	3	G	2	0.0	175	2.5	81.1
-22	4289	14.94	14.7	2	4	V	3	9.1	128	3.0	82.4
-23	6861	21.64	15.9	2	2	G	2	0.0	185	3.5	83.3
-24	4328	16.90	13.1	2	3	G	2	1.9	148	5.0	76.2
-25	3879	14.99	13.1	3	3	Y	1	0.0	155	2.0	78.5
-26	3674	13.02	14.3	2	3	G	2	0.0	178	2.0	79.9
-27	4769	16.59	14.6	2	3	G	1	0.0	175	3.0	82.0
-28	3510	13.05	13.5	3	4	V	4	0.0	173	2.0	80.4
-29	3852	13.54	14.6	2	4	G	4	0.0	125	0.0	80.0
-30	2794	11.76	12.1	3	4	Y	3	0.0	173	3.5	79.5
-31	6133	21.01	14.6	2	2	V	2	2.9	158	4.5	82.5
-32	5225	17.85	14.6	2	3	V	3	0.0	150	3.5	79.9
-33	6266	21.01	15.0	1	3	G	1	0.0	135	1.5	80.5
-34	3280	12.25	13.4	3	4	Y	3	0.0	95	2.5	75.4
-35	6171	20.93	14.8	2	3	V	2	0.0	158	2.5	80.3
-36	4416	14.98	14.5	3	3	Y	3	0.0	178	4.0	81.2
-37	4654	15.75	14.9	3	4	G	3	0.0	185	3.0	77.9
-38	4922	18.48	13.3	2	3	V	2	0.0	190	2.5	79.2
-39	3843	13.77	14.0	2	3	V	2	0.0	155	1.5	78.1
-40	4948	16.59	15.1	2	4	V	3	0.0	163	3.0	80.7
-41	4449	14.70	15.1	2	3	V	3	0.0	160	3.5	79.7
-42	4856	16.59	14.8	1	2	G	1	0.0	160	4.0	78.7
Checks											
F92-790-15H26	4539	15.33	14.8	2	2	Y	2	0.0	173	4.0	81.3
F92-790-15H97	5247	19.53	13.5	2	2	Y	2	0.0	178	3.5	78.7

TEST 3193. RHIZOMANIA EVALUATION/SELECTION OF S_1 MONOGERM LINES, SALINAS, CA., 1993
(cont.)

Variety[1]	Acre Yield		Sucrose	Rz[2]	Vigor[3]	Color[4]	Unif[5]	Root Rot	Beets/ 100'	Powdery Mildew	RJAP
	Sugar Lbs	Beets Tons	%	rating	rating	rating		%	No.	10/18/93	%
Mean	3995.3	13.53	14.8					0.2	162.4	2.9	79.4
LSD (.05)	1726.2	6.30	1.6					2.8	36.7	4.6	5.2
C.V. (%)	21.8	23.51	5.6					731.5	11.4	79.7	3.3
F value	4.1**	3.12**	3.1**					1.0NS	3.4**	1.2NS	2.4**

[1]2859Am(Sp)-#'s, 2865Am(Sp)-#'s, 2867Am(Sp)-#'s, and 2891Am(Sp)-#'s are S_1 lines from their respective populations. The populations segregated for both Rz and monogerm. Unbagged, monogerm, fully fertile plants were tagged in field increases to produce S_1 seed. Some plants in these lines may be from outcrosses within the population and be half-sibs rather than S_1's.
[2]Visual rating of canopy where 1 = homozygous resistant (RzRz), 2 = segregation, 3 = homozygous susceptible.
[3]Vigor rating of canopy where 1 = vigorous to 5 = weak.
[4]Color rating of canopy where G = green, Y = yellowish, V = segregation or variable.
[5]Uniformity of canopy where 1 = highly uniform to 5 = highly variable.

CURLY TOP EVALUATION OF SALINAS ENTRIES AT KIMBERLY, IDAHO, 1993

150 entries x 3 replications

Test Conducted by Terry Brown, BSDF

Variety	Description	CT Grade[1] 1st Rating	CT Grade[1] 2nd Rating
CHECKS			
US 33	Check	4.1*	5.3*
US 41	Check	3.8*	4.5*
HYBRIDS			
US H11	C546H3 x C36	3.3	4.0
WS-PM9	Hilleshog-MH	3.0	4.0
SS-VY1	Spreckels L921068	3.7	4.7
6770	Betaseed	4.0	5.7
N203H20	(C562CMS x C309) x C603	3.7	5.3
R222R4H20	(C562CMS x C309) x R122R3	4.3	5.0
R280H20	87-309H3 x R080	3.7	4.7
R276H20	87-309H3 x R076	3.7	4.7
R278H20	87-309H3 x R078	3.7	4.3
R282H20	87-309H3 x R176-43,-79	3.7	4.7
2915H20	87-309H3 x 1913,1915	3.7	4.7
R280H8	F82-546H3 x R080	3.7	4.3
R280H22	0722HO x R080	3.7	4.7
R280H33	C790-54aa x R080	3.7	4.0
R280H51	1855-59HO x R080	3.7	5.0
R280H52	1852-7HO x R080	3.7	4.3
R280H53	1852-52HO x R080	3.7	4.7
R280H92	F85-796-22HO x R080	3.3	4.7
R280H97	C796-43HO x R080	3.7	4.3
R280H39	89-762-17CMS x R080	3.3	4.3
R278H39	89-762-17CMS x R078	3.7	4.3
2915H39	89-762-17CMS x 1913,1915	3.7	4.7
2915H58	C859aa x 1913,1915	3.7	4.3
2915H68	1867Raa x 1913,1915	3.3	4.3
2915H90	C790aa x 1913,1915	3.3	4.0
R280H90	C790aa x R080	3.3	4.0
R280H93	1890aa x R080	3.0	4.0
R280H91	C790HO x R080	3.0	4.0
R280H65	1865aa x R080	3.3	4.3
R280H68	1867aa x R080	4.3	5.0
R280H64	1864aa x R080	4.3	5.0
R280H62-1	0864-1aa x R080	4.3	5.7
R280H62-5	0864-5aa x R080	4.7	5.7
R280H62-8	0864-8aa x R080	4.3	5.3
R280H62-14	0864-14aa x R080	4.7	5.7
R280H62-19	0864-19aa x R080	4.3	5.3
R280H62-25	0864-25aa x R080	4.7	5.0
R280H52-28	0864-28aa x R080	4.7	5.7
R280H62-34	0864-34aa x R080	4.3	5.3
R280H62-40	0864-40aa x R080	4.0	5.0
US H11	C546H3 x C36	4.0	5.0
2915H65	1865aa x 1913,1915	4.3	5.3

[1]Mean of 3 replications.
* = average of 23 to 26 times repeated in test

CURLY TOP EVALUATION OF SALINAS ENTRIES AT KIMBERLY, IDAHO, 1993

(cont.)

Variety	Description	CT Grade[1] 1st Rating	CT Grade[1] 2nd Rating
HYBRIDS (cont.)			
2865H15	1915aa x 1865,1865-#	4.0	5.0
2865H43-4	C911-4aa x 1865,1865-#	4.0	4.7
2865H43-12	C911-12aa x 1865,1865-#	3.7	4.7
2865H43-14	C911-14aa x 1865,1865-#	3.7	4.7
2865H43-50	C911-50aa x 1865,1865-#	4.0	5.0
2865H45-5	1913-5aa x 1865,1865-#	4.0	4.7
2865H45-18	1913-18aa x 1865,1865-#	4.0	4.7
2854H45-22	1913-22aa x 1865,1865-#	4.0	4.7
2865H45-25	1913-25aa x 1865,1865-#	4.0	4.7
2865H46-1	0911-1aa x 1865,1865-#	4.3	5.0
286546-4(B)	0911-48aa x 1865,1865-#	3.7	4.7
2865H46-24	0911-24aa x 1865,1865-#	4.0	4.7
2865H47-6	0913-6aa x 1865,1865-#	4.0	4.7
2865H47-9	0913-9aa x 1865,1865-#	3.7	4.7
2865H48-1	0915-1aa x 1865,1865-#	4.0	5.0
2865H48-4	0915-4aa x 1865,1865-#	4.0	4.7
2865H48-6	0915-6aa x 1865,1865-#	4.0	5.0
2865H48-7	0915-7aa x 1865,1865-#	4.0	5.0
2865H48-16	0915-16aa x 1865,1865-#	4.0	5.0
2865H48-22	0915-22aa x 1865,1865-#	3.7	5.0
2865H48-23	0915-23aa x 1865,1865-#	3.7	4.7
2865H48-24	0915-24aa x 1865,1865-#	3.7	4.3
2865H48-27	0915-27aa x 1865,1865-#	3.7	4.3
2865H48-34	0915-34aa x 1865,1865-#	3.7	4.3
2865H48-46	0915-46aa x 1865,1865-#	3.7	4.7

Variety	Description	CT Grade 1st Rating	CT Grade 2nd Rating
MULTIGERM, O.P.			
U86-37	C37, 86443	4.0	4.3
R279	Inc. R079 (C37Rz)	3.3	4.3
R279Y	RZM BYV-ER R079	3.7	4.3
R279R2	RZM 1204-#(C)	4.0	4.7
268	Inc. 768 (US 75)	4.0	4.7
R228	RZM 1202-# (C28)	3.7	4.3
R221	Inc. R121 (C48)	3.7	4.0
R280	Inc. R080	4.0	5.0
R280Y	RZM-BYV-ER R080	4.3	5.0
R280-1	Inc. R080-1	4.0	5.3
R280-13	Inc. R080-13	3.7	5.0
R280-28	Inc. R080-28	4.0	5.0
R280-35	Inc. R080-35	4.0	5.0
R280-45	Inc. R080-45	4.0	4.7
R280-56	Inc. R080-56	4.0	5.0
R280-79	Inc. R080-79	4.3	5.3
R280-80	Inc. R080-80	4.3	4.7
R222R4	RZM R122R3	4.7	5.3
R270Y	RZM-BYV-ER R070	4.3	5.0
Y846	Inc. Y746 (C46/2)	4.0	4.0
R278	RZM R078 (C46/2Rz)	4.0	4.3
R278Y	RZM-BYV-ER R078	3.7	4.3
F86-31/6	Inc. C31/6	3.7	5.0
R276	RZM R076 (C31/6Rz)	4.0	5.0
R276Y	BYV-ER R076	4.7	5.3

CURLY TOP EVALUATION OF SALINAS ENTRIES AT KIMBERLY, IDAHO, 1993

(cont.)

Variety	Description	CT Grade[1] 1st Rating	CT Grade[1] 2nd Rating
MULTIGERM, O.P. (cont.)			
R276-43	RZM R176-43	5.0	5.7
R276-89	RZM R176-89	4.7	5.3
R282	Inc. R176-43,-89	5.0	6.3
Y139	BYR Y939, (C39)	4.7	5.3
R239C8	RZM R139C7, (C39R)	4.3	5.0
Y147	BYR Y947, (C47)	4.0	5.3
R247C8	RZM R147C7, (C47R)	4.0	5.0
R232	RZM 1201-#(C)	4.0	5.3
P201	Inc.1211,..,1216(WB97,242)	4.3	5.0
MULTIGERM, S^f, A:aa POPNS & LINES			
R207	RZM R107	4.3	6.0
R208	RZM R108	4.7	6.0
Z220	RZM Z120,Z122,Z124	4.7	6.0
Z230	Z120,Z122,Z124aa x 1915	4.3	5.7
2916	1905aa x 1913,1915	4.0	4.7
5747	4747aa x A	3.3	4.0
2910	Inc. 1210 (C)	3.7	4.3
2914	RZM 1914	3.7	4.3
2911Y	BYV-ER 0911	4.0	4.3
2913	RZM 1913	4.0	4.3
2913Y	RZM-BYV-ER 0913	3.7	4.3
2915	RZM 1915	3.7	4.3
2915Y	BYV-ER 0915	3.7	4.0
2915	1915-#aa x 1913,1915	4.0	4.7

Variety	Description	CT Grade 1st Rating	CT Grade 2nd Rating
NR LINES AND POPNS			
N203H15	1915aa x C603	4.0	4.7
N244	NR-RZM N144-1,-2,-3	4.3	5.3
N254-#	1915aa x N144-#	4.0	5.3
N203	Inc. C603	4.7	6.0
N203-1	Inc. C603-1	5.0	7.3
N204	Inc. 1226-1, (C604)	7.0	8.3
MONOGERM, S^f, A:aa POPNS & LINES			
0790	$8790S_1$(C)aa x A, (C790)	3.7	4.3
2890	C790aa x 1890, RZM 1890	3.7	5.0
2891m	1890aa x A	3.7	4.7
2888m	1866,76,90,1859Raa x A	4.0	4.7
2889m	0790, 0787, 0755aa x A	3.7	4.7
2859	RZM 1859, (C859)	3.7	4.3
2859R	RZM 1859R, (C859)	3.7	4.7
2859m	1859, 1859Raa x A, (C859)	3.7	4.7
2867	RZM 1867	3.7	4.7
2867m	1867, 1867Raa x A	3.7	4.7
2866	Inc. 1866	3.7	4.7
2865m	1865-#, 1865aa x A	4.0	5.7
MONOGERM LINES			
F82-546H3	C562HO x C546	3.7	4.7
87-309H3	C562HO x C309	3.7	4.3
F92-790-6H39	C762-17CMS x C790-6	3.7	4.3

CURLY TOP EVALUATION OF SALINAS ENTRIES AT KIMBERLY, IDAHO, 1993
(cont.)

Variety	Description	CT Grade[1] 1st Rating	CT Grade[1] 2nd Rating
MONOGERM LINES (cont.)			
F92-790-15H39	C762-17CMS x C790-15	3.7	4.3
F92-790-54H39	C762-17CMS x C790-54	3.7	4.3
88-790-68H92	C796-22CMS x C790-68	4.0	5.0
F92-790-6H97	C796-43CMS x C790-6	4.0	4.7
F92-790-15H97	C796-43CMS x C790-15	3.7	4.7
F92-790-54H97	C796-43CMS x C790-54	3.7	4.3
F82-546	Inc. C546	3.7	4.7
87-309	Inc. C309	3.7	4.7
88-790-68	Inc. C790-68	4.0	5.0
F92-790-6	Inc. C790-6	4.0	5.0
F92-790-15	Inc. C790-15	3.7	4.7
F92-790-54	Inc. C790-54	4.0	4.7
91-762-17	Inc. C762-17	3.7	4.3
F82-562	Inc. C562	4.0	4.3

Note: Test was severely infested with black bean aphids making differences in curly top reactions difficult to rate.

TEST 493. BOLTING EVALUATION OF LINES, SALINAS, CA., 1992-93

160 entries x 3 replications
1-row plots, 18 ft. long

Planted: November 12, 1992
Not harvested for yield

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 1					
MM,O.P. lines					
SP 7622-O	L80466 (8/87)	126	83.8	85.3	4.8
Y009	Inc. US 22/3	120	82.6	82.6	6.8
768	Inc. 868 (US 75)	130	28.4	31.2	7.0
268	Inc. 768 (US 75)	115	9.5	9.5	6.7
U86-37	C37, 86443	126	10.6	18.5	5.8
R279 Iso	RZM R079	111	19.7	25.7	5.0
R279Y Iso	RZM-BYV-ER R079	113	26.9	31.7	5.8
R279R2	RZM 1204-#(C)	117	12.8	21.1	7.2
R128	RZM 0271-#	117	33.4	35.4	5.7
R228	RZM 1202-#(C)	102	4.8	4.8	5.2
R130	RZM R030	106	46.3	57.9	5.0
R230	RZM R130	115	37.1	38.4	4.3
R221	RZM R121	76	48.0	48.0	5.5
Y954	Inc. Y854	119	6.3	12.6	5.2
Y054 Iso	BYR-ER-PMR Y854	102	8.7	10.2	4.3
R080 Iso	RZM R980	109	22.2	30.6	4.7
Block 2					
R280 (SpMR)	RZM R080 (Iso)	117	28.8	35.4	5.7
R280 Iso	RZM R080 (Iso)	98	18.4	24.4	5.5
R280Y Iso	RZM-BYV-ER R080	93	13.9	19.9	6.0
R280- 1	Inc. R080- 1	119	14.3	14.3	5.3
-13	Inc. R080-13	100	8.8	16.2	4.5
-28	Inc. R080-28	96	10.2	11.7	3.7
-35	Inc. R080-35	96	1.4	4.4	3.8
-45	Inc. R080-45	95	3.2	3.2	4.0
R280-56	Inc. R080-56	115	7.0	11.9	4.3
-79	Inc. R080-79	130	9.8	18.2	4.5
-80	Inc. R080-80	119	1.6	4.7	4.2
R122R3	RZM R022R2	119	60.6	71.6	7.0
R222R4	RZM R122R3	100	69.4	75.3	7.3
R122Y2	BYR R922Y	107	40.7	40.7	5.3
R070	Inc. R971-R980	104	23.7	34.7	5.8
R270Y	RZM-BYV-ER R070	107	9.1	15.8	5.2

TEST 493. BOLTING EVALUATION OF LINES, SALINAS, CA., 1992-93
(cont.)

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 3					
U86-46/2	C46/2, 86342	133	4.2	8.5	5.3
Y846	Inc. Y746	100	3.3	4.7	5.0
R278 (SpMR)	RZM R078	113	33.7	41.6	6.7
R278 Iso	RZM R078	106	21.1	26.9	6.5
R278Y Iso	RZM-BYV-ER R078	113	6.9	11.1	5.7
F86-31/6	86263, Inc. C31/6	120	15.3	18.4	6.2
R276 (SpMR)	RZM R076	109	42.7	44.6	6.7
R276 Iso	RZM Ro76	111	32.6	35.6	5.8
R276Y Iso	RZM-BYV-ER R076	109	29.6	34.6	6.3
Y231-43	Inc. Y131-43	139	8.4	16.6	4.8
R276-43 Iso	RZM R176-43	113	14.1	25.1	6.5
R281-43	Y131-43 x RZM R176-43,-89	70	21.4	30.6	4.8
Y231-89	Inc. Y131-89	111	0.0	2.1	6.5
R276-89 Iso	RZM R176-89	115	34.1	38.5	5.8
R281-89	Y131-89, x R176-43,-89	91	16.3	27.6	6.0
R282 Sp	Inc. R176-43,-89	111	30.0	43.2	6.2
Block 4					
R283	rr composite x R(C)	120	21.8	25.8	5.3
Y141	BYR Y841	130	10.9	12.6	3.3
Y148	BYR Y948	115	24.4	40.8	5.5
Y049	BYR-ER-PMR Y849	111	35.2	44.7	4.7
Y156	BYR Y956	98	26.5	31.1	5.5
Y139	BYR Y939	117	18.3	29.0	4.7
R039C5	Inc. R939C5	117	36.6	46.6	5.5
R239C8	RZM R139C7	122	41.7	50.6	5.2
Y147	BYR Y947	113	14.8	19.6	4.8
R047C5	Inc. R947C5	113	68.6	72.1	6.0
R247C8	RZM R147C7	122	39.1	49.4	6.5
R204	RZM R104	109	74.1	74.1	6.7
R232	RZM 1201-#(C)	120	61.6	61.6	6.0
P201	PMR 1211,13,15;1212,14,16	113	55.4	57.3	6.0
P202	PMR 1217,19,21,23; 1218,20,22,24	113	48.2	51.0	6.0
U86-37	C37, 86443	115	12.9	14.5	6.3
Block 5 MM,S^1,A:aa lines and populations					
R207	RZM R107	130	33.8	37.8	6.3
R208	RZM R108	122	29.6	40.7	6.2
Z220	RZM Z120,Z122,Z124	109	27.9	40.6	6.5
Z230	RZM Z120,Z122,Z124aa x 1913,191	107	29.4	40.3	6.3

TEST 493. BOLTING EVALUATION OF LINES, SALINAS, CA., 1992-93 (cont.)

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 5					
MM,S^{1},A:aa lines and populations (cont.)					
1905	BYR 9905 (A,aa)	111	26.4	33.1	4.3
2916	1905aa x 1913,1915	98	32.8	35.0	5.3
5747	4747aa x A	120	21.5	32.3	7.5
2910	Inc. 1210(C)	111	13.2	19.9	7.2
R129	RZM 0281-#	113	32.2	33.5	7.3
R229	Inc. 1206(C)	124	43.2	56.0	7.5
R229-4-1	Inc. R029-4-1	135	43.8	45.2	6.7
R233	Inc. 1205(C)	111	75.3	76.8	7.2
2910-1-1	Inc. 1910-1-1	115	0.0	0.0	7.3
2910-12-1	Inc. 1910-12-1	89	48.0	48.0	6.2
2914	RZM 1914	111	6.6	14.8	6.0
U86-37	C37, 86443	126	12.2	27.0	6.5
Block 6					
SP7622-O	L80466 (8/87)	133	92.0	92.0	6.0
9903	YR-ER-PMR 7903 (A,aa)	109	8.9	19.0	5.7
8909 (Sp)	7909aa x A	133	16.8	23.7	5.3
9911 (Sp)	8911aa x A	133	6.9	11.1	5.7
0911 (Sp)	9911(Iso)aa x A	122	13.5	25.5	6.3
2911Y Iso	RZM-BYV-ER 0911,0911	117	15.8	23.9	5.8
2911- 4	RZM 1911- 4	95	0.0	4.2	5.3
2911-12	RZM 1911-12	122	6.1	9.3	6.2
2911-14	RZM 1911-14	113	20.1	33.7	5.5
2911-50	RZM 1911-50	111	14.3	26.8	5.5
9912	RZM 8908,9,10,11aa x A	109	32.1	33.8	6.5
2912- 3	RZM 1912- 3	117	31.2	31.2	6.5
2912-11	RZM 1912-11	122	19.9	27.8	7.0
0909- 7	Inc. 8909A- 7	100	63.0	68.5	6.0
0909-34	Inc. 8909A-34	98	26.6	47.2	5.0
0909-37	Inc. 8909A-37	113	21.3	27.7	4.7
Block 7					
2913 Iso	RZM 1913 (A,aa)	104	12.8	17.4	5.3
2913Y Iso	RZM-BYV-ER 0913	106	19.5	19.5	5.3
2913 5	RZM 1913- 5	115	6.2	8.0	5.0
2913-18	RZM 1913-18	107	28.7	33.5	5.2
2913-22	RZM 1913-22	128	14.6	21.8	5.5
2913-25	RZM 1913-25	96	8.3	14.9	5.2
2915 Iso	RZM 1915-#(C) (A,aa)	109	5.2	6.6	4.7
2915Y Iso	RZM-BYV-ER 0915	120	1.4	10.5	5.8

TEST 493. BOLTING EVALUATION OF LINES, SALINAS, CA., 1992-93
(cont.)

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 7 (cont.)					
2915 Sp	RZM 1915-#,1913-#aa x A	122	31.0	32.4	5.7
0911-1	9911aa x 9911,9911H49	130	1.6	2.9	4.8
0911-4(B)	9911aa x 9911,9911H49	117	9.7	14.7	6.0
2911-24	Inc. 0911-24 (A,aa)	130	30.1	31.5	7.2
0913-6	9911H49aa x 9911,9911H4	122	0.0	2.9	7.0
2913-9	Inc. 0913-9 (A,aa)	102	0.0	14.3	6.3
0915-1	9903aa x 9911,9911H49	98	26.5	34.6	6.3
2915-4	Inc. 0915-4 (A,aa)	120	18.5	45.3	5.8
Block 8					
0915-6	9903aa x 9911,9911H49	93	13.6	17.6	5.7
2915-7	Inc. 0915-7 (A,aa)	100	0.0	3.0	4.5
U86-37	C37, 86443	113	10.0	18.2	5.8
0915-22	9903aa x 9911,9911H49	107	0.0	0.0	5.5
0915-23	9903aa x 9911,9911H49	87	13.9	16.7	4.8
0915-24	9903aa x 9911,9911H49	119	10.9	21.8	4.8
0915-27	9903aa x 9911,9911H49	93	11.8	15.4	4.2
0915-34	9903aa x 9911,9911H49	80	9.7	12.2	5.5
2915-46	Inc. 0915-46 (A,aa)	119	3.0	6.1	3.8
0915(C)	9903aa x 9911,9911H	117	9.4	10.9	5.2
1915	RZM 0915 (A,aa)	117	2.2	9.4	5.2
monogerm, S^f,A:aa populations					
0790	8790-S_1(C5)aa x A	126	4.2	11.4	6.8
2890Sp	0790mmaa x 1890,RZM 1890	93	3.9	8.1	6.7
2890HO	0790HO x 1890,RZM 1890	78	3.3	6.7	6.5
2891m	1890mmaa x A	111	6.3	16.4	6.5
2888m	Composite B aa x (C)A&B	96	24.8	32.4	7.0
Block 9					
2889m	Composite C aa x (C)A&B	91	31.4	31.4	6.2
2889mHO	1890HO x Composite A & B	82	15.5	21.6	6.7
2859 Iso	RZM 1859	111	17.4	20.1	7.7
2859R Iso	RZM 1859R	113	11.7	13.4	6.8
2859m Sp	1859,1859Raa x A	111	34.3	34.3	8.0
2859M Sp	1859,1859Raa x A	117	25.6	29.0	7.0
2859m HO	0859HO x 1859,1859R	107	27.7	33.0	7.2
2864 Iso	RZM 1864	115	36.0	47.2	7.0
1867	NB 9867m (A,aa)	106	26.7	31.5	5.8
2867 Iso	RZM 1867 (A,aa)	98	17.0	17.0	6.7
2867m Sp	1867,1867Raa x A	102	14.5	23.5	7.2

TEST 493. BOLTING EVALUATION OF LINES, SALINAS, CA., 1992-93
(cont.)

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 9 (cont.)					
2867m HO	0867HO x 1867,1867R	95	32.7	40.4	6.7
2866	RZM 1866 (A,aa)	132	12.8	22.8	6.8
2865 Iso	RZM 1865-#(C) (A,aa)	113	41.9	48.0	7.5
2865m Sp	1865-#,RZM 1865-#, 1865aa x A	126	57.7	60.7	7.8
2865HO	87-309CMS x 1865,1865-#	109	40.4	54.8	7.8
Block 10					
NR Lines and Selections					
N801(A)Sp	Inc. B883	93	94.9	94.9	9.0
N203 Sp	Inc. N103	120	95.5	97.0	9.0
N203-1 Sp	Inc. N103-1	100	90.0	100.0	9.0
N203-1 Iso	NR-RZM N103-1	59	89.5	97.0	9.0
N204	Inc. 1226-1	98	100.0	100.0	8.5
N205	Inc. 1227-3	113	29.1	30.6	7.3
N206	Inc. 1227-7	102	30.6	47.4	7.3
N207	Inc. 1227-12	72	30.8	44.1	7.3
N244 Iso	NR-RZM N144-1-#(C)	102	41.6	46.0	8.0
N254-#-#(C)	1915aa x N144-#	69	12.8	16.1	7.2
N203H15	1915aa x N103,N103-1	95	36.2	44.6	8.3
N203H18	790-68H23 x N103,N103-1	98	39.9	63.3	8.8
N203H20	309H3 x N103,N103-1	95	41.6	73.3	8.7
N203H89	790-68CMS x N103,N103-1	95	66.5	71.2	9.0
N203H15	1915aa x N103,N103-1	100	43.0	47.2	8.0
N203 Sp	Inc. N103	113	75.1	88.0	8.7
Mean		109.6	26.7	32.7	6.1
LSD (.05)		29.1	16.7	18.4	1.5
C.V. (%)		16.5	38.9	35.0	15.7
F value		1.8**	14.4**	12.2**	4.7**

TEST 193. EVALUATION/SELECTION FOR RESISTANCE TO BOLTING, SALINAS, CA., 1992-93

27 entries; 10,15, and 30 blocks long
1-row plots, 18 ft. long

Planted: November 12, 1992
Not Harvested For Yield

Variety	Description	Beets/ 100'	% Bolting		Powdery Mildew
		No.	07/08	09/21	Mean*
Border and/or Evaluation/Selection					
R282	RZM R176-43,-89	112	32.3	36.3	5.3
R283	rr Composite x R(C)	105	25.3	29.3	4.9
R278 (SpMR)	RZM R078	106	32.1	43.6	6.5
R280 (SpMR)	RZM R080	111	27.3	31.0	5.4
MM,S^sS^s lines					
R270Y	RZM-BYV-ER R070	101	13.1	17.1	5.9
R276Y	RZM-BYV-ER R076	93	28.4	34.0	6.3
R276-43	RZM R176-43	112	26.9	30.6	5.0
R276-89	RZM R176-89	125	29.4	29.7	5.8
R276	RZM R076	118	31.9	34.7	5.0
R280	RZM R080	120	18.2	21.3	5.8
R280Y	RZM-BYV-ER R080	124	24.0	27.3	5.8
R278	RZM R078	116	20.7	32.3	5.0
R278Y	RZM-BYV-ER R078	124	14.8	15.2	5.1
MM,S^f,A:aa populations					
2915Y	RZM-BYV-ER 0915 (A,aa)	120	9.1	11.1	4.2
2915 (Sp)	RZM 1913-#,1915-#aa x A	132	31.4	31.4	3.9
2915	RZM 1915-# (A,aa)	97	28.6	34.4	3.0
2913	RZM 1913 (A,aa)	123	4.8	4.8	5.0
2913Y	RZM-BYV-ER 0913 (A,aa)	115	16.3	16.3	4.4
2911Y	RZM-BYV-ER 0911 (A,aa)	118	22.8	22.8	5.3
mm,S^f,A:aa populations and lines					
2859	RZM 1859 (A,aa)	89	13.1	13.1	5.0
2859R	RZM 1859 (A,aa)	107	19.3	19.3	8.0
2859m (Sp)	1859,1859Raa x A	67	52.1	52.1	8.0
2865m (Sp)	1865-#,RZM1865aa x A	138	56.0	56.0	6.3
2890 (Sp)	0790mmaa x 1890, RZM1890	108	5.3	7.2	6.1
F92-790-6	Inc. C790-6	55	5.7	6.0	4.9
F92-790-15	Inc. C790-15	82	11.5	18.5	3.8
F92-790-54	Inc. C790-54	84	4.9	6.9	4.7

*PM Mean = Average of reading taken 07/02 & 08/03/93.

Up to 1200 feet of row per entry were grown for the purpose of evaluating and selecting for nonbolting tendency. Nonbolted mother roots reselected on the basis of % sugar were selected from lines R276Y, R276-43, R276-89, R276, R280, R280Y, R278, R278Y, 2915, 2865m, and F92-790-15. Seed will be produced in 1994.

TEST 593. BOLTING EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1992-93

160 entries x 3 replications
1-row plots, 18 ft. long

Planted: November 12, 1992
Not harvested for yield

Variety	Description	Beets 100′ No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 1					
US H11	L113401	120	12.6	17.3	6.3
WS-PM9	2/4/91	115	26.3	27.9	5.8
SS-NB3	11/9/92	132	1.3	9.9	5.7
HH 41	L412307 (9/14/92)	109	12.4	19.6	5.5
Rhizosen	L493304 (9/11/92)	109	29.9	42.2	5.5
Rhizoguard	893301 (9/14/92)	135	33.0	33.0	6.2
R222R4H20	87-309H3 x R122R3	106	48.5	56.9	7.3
N203H18	88-790-68H26 x N103	98	32.1	37.8	8.5
R276H18	88-790-68H26 x R076	117	27.2	33.7	5.5
R278H18	88-790-68H26 x R078	102	31.3	35.9	6.3
R282H18	88-790-68H26 x R176-43,-89	61	52.6	60.0	5.7
2915H18	88-790-68H26 x 1913,1915	70	24.9	35.6	5.8
R280H18	88-790-68H26 x R080	100	23.1	29.2	6.2
R080H23	87-309H37 x R980	100	33.4	48.3	5.8
R280H89	88-790-68CMS x R080	91	23.4	30.0	5.3
R282H89	88-790-68CMS x R176-43,-89	48	47.2	47.2	5.0
Block 2					
R280H3	F82-562HO x R080	128	19.2	20.6	6.0
R280H8	F82-546H3 x R080	117	30.4	39.9	5.7
R280H36	0833HO x R080	111	24.2	27.1	5.8
R280H22	0722HO x R080	128	14.5	21.8	6.2
R280H29	0790-6aa x R080	100	12.9	24.2	6.5
R080H29	8790A-6aa x R980	93	10.0	11.8	5.2
R080H30	8790A-15aa x R980	63	21.8	21.8	4.2
R280H33	0790-54aa x R080	104	21.2	21.2	5.3
R080H33	8790A-54aa x R980	89	20.0	24.1	5.7
R080H72	83-718HO x R980	89	6.3	10.6	5.8
R080H34	8790A-55aa x R980	98	14.6	18.5	5.5
R280H50	1855-24HO x R080	78	46.7	64.1	5.5
R280H51	1855-59HO x R080	96	18.9	21.2	6.3
R280H52	1852-7HO x R080	54	19.7	21.9	5.3
R280H53	1852-52HO x R080	107	16.4	22.1	5.8
R280H92	F85-796-22HO x R080	95	15.6	29.9	6.2

TEST 593. BOLTING EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1992-93
(cont.)

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 3					
R280H97	0796-43HO x R080	113	27.7	44.8	6.5
R276H23	87-309H37 x R076	130	30.6	38.9	6.2
R278H37	84-306CMS x R078	128	52.3	56.0	5.5
R280H37	84-306CMS x R080	115	24.4	37.6	5.8
R282H37	84-306CMS x R176-43,-89	104	20.1	24.0	5.5
R278H39	89-762-17CMS x R078	122	46.0	51.5	7.3
R280H39	89-762-17CMS x R080	124	27.8	34.1	6.7
2915H39	89-762-17CMS x 1913,1915	95	9.4	17.1	6.3
R280H26	87-309CMS x R080	89	27.2	35.9	7.2
R282H26	87-309CMS x R176-43,-89	70	34.5	38.4	7.2
2915H26	87-309CMS x 1913,1915	111	35.3	35.3	7.7
R080H39	89-762-17CMS x R980	91	8.2	14.7	6.3
R280H20	87-309H3 x R080	119	28.5	34.7	7.8
R280-1H20	87-309H3 x R080-1	120	22.1	30.0	7.5
R280-13H20	87-309H3 x R080-13	115	2.9	4.7	6.3
R280-28H20	87-309H3 x R080-28	85	11.6	21.6	6.0
Block 4					
R280-35H20	87-309H3 x R080-35	95	35.9	39.1	7.3
R280-45H20	87-309H3 x R080-45	111	1.5	3.0	5.7
R280-56H20	87-309H3 x R080-56	85	16.0	16.0	6.3
R280-79H20	87-309H3 x R080-79	119	16.8	16.8	6.8
R280-80H20	87-309H3 x R080-80	109	17.1	17.1	6.0
R276H20	87-309H3 x R076	132	29.5	48.0	6.5
R278H20	87-309H3 x R078	111	34.6	63.1	7.7
R282H20	87-309H3 x R176-43,-89	89	23.2	25.2	7.0
2915H20	87-309H3 x 1913,1915	120	27.8	35.5	7.5
2911-4H20	87-309H3 x RZM 1911- 4	113	6.7	11.4	7.0
2911-12H20	87-309H3 x RZM 1911-12	109	18.0	23.3	7.3
2911-14H20	87-309H3 x RZM 1911-14	89	24.0	46.7	6.8
2911-50H20	87-309H3 x RZM 1911-50	78	15.6	26.6	6.3
2912- 3H20	87-309H3 x RZM 1912- 3	106	23.7	29.6	7.0
2912-11H20	87-309H3 x RZM 1912-11	91	15.9	17.5	7.3
2913- 5H20	87-309H3 x RZM 1913- 5	74	12.9	20.2	7.8
Block 5					
2913-18H20	87-309H3 x RZM 1913-18	98	17.5	28.5	7.3
2913-22H20	87-309H3 x RZM 1913-22	87	31.2	42.4	6.3
2913-25H20	87-309H3 x RZM 1913-25	82	25.8	42.8	6.8
2911-24H20	87-309H3 x 0911-24	111	17.0	22.4	7.3
2913-9H20	87-309H3 x 0913-9	82	3.5	3.5	7.2
2915-4H20	87-309H3 x 0915-4	111	21.9	27.9	7.5
2915-7H20	87-309H3 x 0915-7	111	6.2	8.1	7.5
2915-46H20	87-309H3 x 0915-46	78	6.5	9.3	7.7

TEST 593. BOLTING EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1992-93
(cont.)

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 5 (cont.)					
N203H15	1915aa x N103,N103-1	109	22.3	30.0	8.2
2859H15	1915aa x 1859,1859R	93	15.5	17.7	6.5
2867H15	1915aa x 1867,1867R	83	31.5	40.6	5.8
2865H15	1915aa x 1865,1865-#	115	28.8	38.7	6.5
2865H13	1913aa x 1865,1865-#	117	25.1	26.8	6.8
2865H43- 4	1911- 4aa x RZM 1865-#	107	20.7	30.7	6.7
2865H43-12	1911-12aa x RZM 1865-#	113	13.5	20.0	6.5
2865H43-14	1911-14aa x RZM 1865-#	113	28.5	34.5	6.8
Block 6					
2865H43-50	1911-50aa x RZM 1865-#	113	24.1	32.1	6.8
2865H44- 3	1912- 3aa x RZM 1865-#	115	51.8	51.8	6.3
2865H44-11	1912-11aa x RZM 1865-#	111	29.7	31.1	6.3
2865H45- 5	1913- 5aa x RZM 1865-#	115	9.8	18.6	5.7
2865H45-18	1913-18aa x RZM 1865-#	102	31.1	36.5	5.7
2865H45-22	1913-22aa x RZM 1865-#	104	18.6	20.1	5.8
2865H45-25	1913-25aa x RZM 1865-#	117	31.6	39.2	5.3
2865H46- 1	0911- 1aa x RZM 1865-#	122	15.2	21.4	5.5
2865H46-4(B)	0911-4(B)aa x RZM 1865-#	122	23.8	34.5	7.0
2865H46-24	0911-24aa x RZM 1865-#	104	17.6	23.1	6.7
2865H47-6	0913- 6aa x RZM 1865-#	111	10.4	16.6	6.7
2865H47-9	0913- 9aa x RZM 1865-#	111	11.0	19.4	7.0
2865H48-1	0915- 1aa x RZM 1865-#	107	21.6	24.9	6.5
2865H48-4	0915- 4aa x RZM 1865-#	117	13.8	23.0	6.7
2865H48-6	0915- 6aa x RZM 1865-#	111	14.6	18.1	6.3
2865H48-7	0915- 7aa x RZM 1865-#	85	22.3	27.8	6.8
Block 7					
2865H48-16	0915-16aa x RZM 1865-#	126	36.5	45.6	6.7
2865H48-22	0915-22aa x RZM 1865-#	106	26.4	28.1	5.8
2865H48-23	0915-23aa x RZM 1865-#	126	30.4	38.7	6.3
2865H48-24	0915-24aa x RZM 1865-#	120	29.5	32.5	6.0
2865H48-27	0915-27aa x RZM 1865-#	128	24.7	27.7	6.2
2865H48-34	0915-34aa x RZM 1865-#	126	40.3	44.4	7.0
2865H48-46	0915-46aa x RZM 1865-#	109	20.3	32.7	6.2
2915H65	1865aa x 1913,1915	76	37.9	43.1	7.0
2915H58	1859Raa x 1913,1915	107	27.7	31.2	7.3
2915H68	1867Raa x 1913,1915	113	28.0	36.3	6.8
2915H90	0790aa x 1913,1915	85	19.8	24.6	6.8
R280H90	0790aa x R080	76	24.3	32.8	6.7
R280H91	0790HO x R080	87	17.2	16.8	5.5
R280H93	1890aa x R080	120	32.5	36.6	6.7
R280H58	1859Raa x R080	102	23.9	27.6	6.8
R280H65	1865aa x R080	113	51.4	51.4	6.8

TEST 593. BOLTING EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1992-93
(cont.)

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Block 8					
R280H66	1865-#(C)aa x R080	100	35.2	43.6	6.8
R280H68	1867Raa x R080	98	34.5	43.7	6.5
R280H64	1864aa x R080	80	42.0	54.6	5.8
R280H62- 1	0864- 1aa x R080	93	33.6	41.2	5.8
R280H62- 5	0864- 5aa x R080	56	44.4	56.5	5.3
R280H62- 8	0864- 8aa x R080	104	28.5	35.8	6.0
R280H62-14	0864-14aa x R080	106	42.5	42.5	6.0
R280H62-19	0864-19aa x R080	72	56.8	60.2	6.2
R280H62-25	0864-25aa x R080	70	23.5	23.5	6.2
R280H62-28	0864-28aa x R080	74	33.6	41.4	5.7
R280H62-34	0864-34aa x R080	109	27.0	34.9	5.7
R280H62-40	0864-40aa x R080	100	46.3	47.9	5.8
R280H63	0864HO x R080	102	19.9	31.0	6.0
US H11	L113401SS-NB3	120	22.2	23.6	6.5
SS-NB3	11/9/92	119	3.1	6.1	6.2
Rhizoguard	893301	104	33.1	37.3	7.0
monogerm, self-fertile lines					
F82-546H3	82460, C562HO x C546	143	10.5	22.2	7.3
87-309H3	87671, C562HO x C309	126	39.8	45.7	8.2
87-309H37	87242, C306HO x C309	128	15.8	22.8	7.0
88-790-68H37	88191, C306HO x C790-68	102	23.7	34.5	6.2
88-790-68H26	88189, C309HO x C790-68	113	21.2	32.8	8.5
F92-790-6H26	921186, C309HO x C790-6	115	10.0	18.7	7.8
F92-790-15H26	921191, C309HO x C790-15	87	10.7	16.2	6.8
F92-790-54H26	921196, C309HO x C790-54	104	10.6	19.5	7.0
F92-790-6H39	921187, C762-17CMS x C790-6	95	3.9	9.5	5.5
F92-790-15H39	921192, C762-17CMS x C790-15	126	14.6	19.4	4.2
F92-790-54H39	921197, C762-17CMS x C790-54	119	6.3	13.0	5.0
88-790-68H92	88190, C796-22CMS x C790-68	124	11.9	17.9	6.3
F92-790-6H97	921188, C796-43CMS x C790-6	85	4.3	11.2	6.5
F92-790-15H97	921193, C796-43CMS x C790-15	111	14.9	18.1	5.8
F92-790-54H97	921198, C796-43CMS x C790-54	106	1.7	16.5	6.2
F82-562	82196, C562	119	34.3	45.0	7.5

TEST 593. BOLTING EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1992-93
(cont.)

Variety	Description	Beets 100'	% Bolting		Powdery Mildew
		No.	07/08	09/01	Mean
Block 10					
F82-546	82372, C546	124	24.9	33.7	7.5
87-309	87672, C309	111	26.9	49.8	7.7
88-790-68	88192, C790-68	113	30.7	42.1	6.7
88-790-68CMS	88187, C790-68CMS	113	9.2	23.5	6.0
F92-790-6	921189, C790-6	107	0.0	0.0	5.3
F92-790-6CMS	921185, C790-6CMS	98	5.8	11.5	6.5
F92-790-15	921194, C790-15	115	9.7	21.2	4.0
F92-790-15CMS	921190, C790-15CMS	93	7.9	14.1	5.3
F92-790-54	921199, C790-54	113	1.7	3.2	5.0
F92-790-54CMS	921195, C790-54CMS	67	12.7	27.6	6.0
89-762-17	89121, C762-17	83	24.4	36.5	5.8
91-762-17	10/22/91, C762-17	78	3.3	5.2	6.2
91-767-46	10/22/91, C767-46	91	53.1	55.5	6.7
F82-562HO	82195, C562HO	120	36.6	44.5	7.8
1512	Inc. 6512 (NB6)(1981)	87	0.0	0.0	7.3
9600 (A)	Inc. 8600 (Annual)	115	100.0	100.0	---
Mean		103.5	23.4	29.9	6.4
LSD (.05)		28.4	18.2	19.5	1.5
C.V. (%)		17.1	48.4	40.5	14.3
F value		3.1**	4.5**	4.5**	2.4**

TEST 393. BOLTING EVALUATION/SELECTION OF LINES WITHIN POPN-859, SALINAS, CA., 1992-93

30 entries x 1 replication
1-row plots, 18 ft. long

Planted: November 12, 1992
Not harvested for yield

Variety	Description	Beets 100'	% Bolting		Powdery Mildew
		No.	07/08	09/01	Mean
Lines from popn-859					
2859Am(Sp)- 1	Inc. 1859,1859R (A-)	89	6.3	25.0	5.0
- 2		117	33.3	33.3	4.0
- 3		122	9.1	13.6	6.5
- 4		89	31.3	31.3	5.5
- 5		67	33.3	33.3	7.0
- 6		83	33.3	33.3	7.0
- 7		95	29.4	29.4	6.5
- 8		56	90.0	90.0	7.5
- 9		106	15.8	26.3	8.5
-10		56	20.0	20.0	8.5
-11		111	25.0	25.0	9.0
-12		89	25.0	25.0	7.0
-13		117	28.6	28.6	7.0
-14		95	76.5	76.5	7.5
-15		95	17.6	23.5	8.5
-16		95	23.5	23.5	7.0
-17		111	45.0	45.0	7.5
-18		67	100.0	100.0	5.0
-19		111	20.0	20.0	6.5
-20		95	17.6	17.6	8.0
-21		72	15.4	15.4	8.0
-22		106	26.3	26.3	7.0
-23		83	6.7	20.0	6.5
-24		78	42.9	42.9	6.0
-25		100	11.1	16.7	6.5
-26		111	20.0	30.0	6.5
-27		56	50.0	50.0	5.5
-28		128	0.0	8.7	6.5
-29		89	6.3	18.8	6.5
-30		106	10.5	10.5	8.5

Note: See test 3193, S_1 progeny test of monogerm lines for rhizomania resistance. Progeny lines of 2859Am were evaluated for nonbolting tendency (Test 393) and resistance to rhizomania (Test 3193). Stecklings from the best lines have been selected and will be topcrossed using genetic male sterile segregates to determine GCA. Popn-859 is nearly equal to C859.

TEST 293. BOLTING EVALUATION/SELECTION OF LINES WITHIN POPN-790 LINES, SALINAS, CA., 1992-93

60 entries x 1 replication
1-row plots, 18 ft. long

Planted: November 12, 1992
Not harvested for yield

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Lines C790-6					
2790-6- 1	0790-6-#	100	0.0	0.0	1.5
- 2		117	0.0	0.0	4.5
- 3		100	0.0	0.0	5.0
- 4		145	0.0	7.7	5.0
- 5		72	0.0	7.7	5.5
- 6		56	0.0	10.0	3.5
- 7		100	0.0	22.2	5.0
- 8		106	0.0	31.6	5.5
- 9		39	0.0	42.9	6.0
Lines C790-15					
2790-15- 1	0790-15-#	106	5.3	5.3	5.0
- 3		78	50.0	50.0	7.0
- 5		89	31.3	31.3	5.0
- 6		78	21.4	21.4	4.5
- 7		83	20.0	20.0	4.5
- 9		78	14.3	35.7	4.5
-10		89	43.8	43.8	8.5
-11		72	15.4	23.1	3.0
-12		106	10.5	15.8	4.0
-13		106	31.6	31.6	4.0
-14		100	0.0	38.9	4.5
-15		89	0.0	12.5	4.0
-16		78	7.1	7.1	4.5
-17		111	35.0	35.0	4.5
-18		111	45.0	45.0	4.0
-19		89	6.3	6.3	5.5
-20		39	14.3	14.3	4.0
-21		106	5.3	5.3	4.0
-22		106	10.5	10.5	3.5
-23		72	0.0	0.0	4.5
-24		33	0.0	0.0	6.5

TEST 293. BOLTING EVALUATION/SELECTION OF LINES WITHIN POPN-790 LINES, SALINAS, CA., 1992-93
(cont.)

Variety	Description	Beets 100' No.	% Bolting 07/08	% Bolting 09/01	Powdery Mildew Mean
Line C790-54					
2790-54- 1	0790-54-#	117	0.0	19.0	2.5
- 2		133	0.0	8.3	3.0
- 3		122	9.1	18.2	3.0
- 4		106	0.0	31.6	3.0
- 5		111	0.0	20.0	4.5
- 6		106	42.1	42.1	5.5
- 7		56	30.0	60.0	5.5
- 8		44	0.0	37.5	4.5
- 9		100	16.7	16.7	6.0
-10		100	0.0	50.0	6.5
-11		89	0.0	0.0	6.0
-12		78	0.0	50.0	4.5
-13		78	7.1	14.3	5.0
-14		67	0.0	0.0	5.0
-15		83	0.0	6.7	4.5
-16		67	8.3	8.3	5.0
-17		67	0.0	8.3	4.5
-18		95	5.9	29.4	3.5
-19		128	39.1	39.1	5.0
-20		67	0.0	0.0	6.0
-21		117	57.1	57.1	6.0
-22		67	8.3	33.3	5.0
-23		56	30.0	30.0	5.5
-24		117	28.6	28.6	4.5
-25		111	0.0	45.0	6.5
F92-790-15	Inc. C790-15	111	10.0	10.0	4.5
F92-790-15	Inc. C790-15	100	33.3	33.3	4.5
F92-790-15	Inc. C790-15	122	18.2	18.2	4.0
F92-790-15	Inc. C790-15	100	16.7	16.7	6.0
F92-790-15	Inc. C790-15	56	30.0	30.0	6.5

Single plants of C790-6, C790-15, and C790-54 were selfed under bags in the greenhouse. The selfed progeny were planted for evaluation and selection for nonbolting tendency. Among line variability suggests genetic difference for bolting resistance. Based upon these data, a mother root and steckling nonbolting selection was made within C790-15. Seed will be produced in 1994.

TEST 2093. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1993

160 entries x 3 replications
1-row plots, 18 ft. long

Planted: April 20,1993
E.c.b. Inoc.: July 15, 1993
Scored: October 6, 1993

Variety	Description[1]	Stand Count/ Plot	Harv. Count/ Plot	Erwinia Reaction[2] DI	Erwinia Reaction[2] % Resistant	P.M. Avg.[3]
Experimental Hybrids						
Block 1						
US H11	L113401	23	22	5.1	79.6	6.2
E840	Inc. E440, E640 (C40)	25	23	98.3	1.7	7.0
E840H72	83-718HO x E440, E640	24	25	91.6	5.3	7.1
E840H8	F82-546H3 x E440, E640	19	21	64.8	17.4	6.1
Rhizosen	L493304 (9/11/92)	25	23	43.5	36.8	4.0
Rhizoguard	893301 (9/14/92)	23	21	54.0	33.3	4.8
R222R4H20	87-309H3 x R122R3	24	23	51.4	33.7	6.7
N203H18	88-790-68H26 x N103 (C603)	22	21	79.5	12.2	8.0
R276H18	88-790-68H26 x R076	25	23	42.2	42.7	4.2
R278H18	88-790-68H26 x R078	24	24	39.8	44.0	4.6
R282H18	88-790-68H26 x R176-43,-89	24	23	37.2	47.0	4.2
2915H18	88-790-68H26 x 1913,1915	24	25	29.8	51.6	4.9
R280H18	88-790-68H26 x R080	25	24	21.4	60.2	4.8
R080H23	87-309H37 x R980	21	20	23.0	66.2	5.1
R280H89	88-790-68CMS x R080	25	21	41.3	37.4	4.7
R282H89	88-790-68CMS x R176-43,-89	18	18	39.7	41.7	4.0
Block 2						
R280H3	F82-562HO x R080	22	21	24.2	63.5	5.8
R280H8	F82-546H3 x R080	25	24	23.5	58.6	5.4
R280H36	0833HO x R080	26	25	47.0	37.3	5.8
R280H22	0722HO x R080	24	24	20.6	67.7	4.4
R280H29	C790-6aa x R080	23	22	28.4	55.9	4.8
R080H29	C790A-6aa x R980	25	22	23.7	59.3	3.7
R080H30	C790A-15aa x R980	20	21	17.1	63.6	2.4
R280H33	C790-54aa x R080	23	22	15.8	69.3	3.0

TEST 2093. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1993

(cont.)

Variety	Description[1]	Stand Count/ Plot	Harv. Count/ Plot	Erwinia Reaction[2] DI	Erwinia Reaction[2] % Resistant	P.M. Avg.[3]
Block 2 (cont.)						
R080H33	C790A-54aa x R980	21	20	13.3	70.0	3.7
R080H72	83-718HO x R980	23	21	50.4	33.8	4.8
R080H34	C790A-55aa x R980	23	23	11.1	79.8	4.2
E840	Inc. E440 (C40)	26	23	98.0	0.0	8.2
R280H51	1855-59HO x R080	25	26	34.9	43.8	5.2
R280H52	1852-7HO x R080	25	24	42.3	43.5	4.7
R280H53	1852-52HO x R080	22	24	24.2	57.8	5.7
R280H92	F85-796-22HO x R080	24	24	38.5	36.1	5.8
Block 3						
R280H97	C796-43HO x R080	22	21	29.0	48.6	5.7
R276H23	87-309H37 x R076	24	23	45.8	35.7	5.0
R278H37	84-306CMS x R078	23	23	56.9	24.0	5.0
R280H37	84-306CMS x R080	21	20	51.8	25.3	5.1
R282H37	84-306CMS x R176-43,-89	21	21	69.7	11.0	4.3
R278H39	89-762-17CMS x R078	24	24	48.1	36.2	3.9
R280H39	89-762-17CMS x R080	23	23	54.5	27.4	4.3
2915H39	89-762-17CMS x 1913,1915	21	20	50.3	30.9	4.3
Topcross Hybrids						
R280H26	87-309CMS x R080	25	23	40.8	40.6	5.2
R282H26	87-309CMS x R176-43,-89	22	21	22.5	61.2	5.8
2915H26	87-309CMS x 1913,1915	25	28	36.6	46.4	6.1
R080H39	89-762-17CMS x R980	24	21	45.5	31.7	4.1
R280H20	87-309H3 x R080	22	23	36.2	45.8	5.6
R280-1H20	87-309H3 x R080-1	26	24	24.8	50.7	5.1
R280-13H20	87-309H3 x R080-13	25	26	22.0	59.7	5.0
R280-28H20	87-309H3 x R080-28	23	23	18.9	67.8	5.2

TEST 2093. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1993

(cont.)

Variety	Description[1]	Stand Count/ Plot	Harv. Count/ Plot	Erwinia Reaction[2] DI	Erwinia Reaction[2] % Resistant	P.M. Avg.[3]
Block 4						
R280-35H20	87-309H3 x R080-35	25	25	44.2	41.3	5.1
R280-45H20	87-309H3 x R080-45	27	26	11.9	68.2	4.6
R280-56H20	87-309H3 x R080-56	24	24	11.4	75.9	5.0
R280-79H20	87-309H3 x R080-79	25	25	13.1	64.0	5.3
R280-80H20	87-309H3 x R080-80	25	25	16.9	74.5	4.7
R276H20	87-309H3 x R076	27	26	27.6	53.0	5.1
R278H20	87-309H3 x R078	26	24	39.5	46.7	6.0
R282H20	87-309H3 x R176-43,-89	24	23	38.2	37.7	5.3
2915H20	87-309H3 x 1913,1915	23	21	20.4	68.3	5.6
2911-4H20	87-309H3 x RZM 1911- 4	25	23	13.0	70.7	4.8
2911-12H20	87-309H3 x RZM 1911-12	27	26	20.8	53.2	5.4
2911-14H20	87-309H3 x RZM 1911-14	26	26	42.8	35.7	5.9
2911-50H20	87-309H3 x RZM 1911-50	25	24	10.7	66.4	5.0
E840	Inc. E440 (C40)	24	25	93.3	5.5	7.1
US H11	L113401	26	26	7.4	84.3	5.4
2913- 5H20	87-309H3 x RZM 1913- 5	25	25	19.7	68.7	5.6
Block 5						
2913-18H20	87-309H3 x RZM 1913-18	22	20	12.2	68.7	5.3
2913-22H20	87-309H3 x RZM 1913-22	22	21	18.4	56.8	5.1
2913-25H20	87-309H3 x RZM 1913-25	23	23	7.3	76.8	5.2
2911-24H20	87-309H3 x 0911-24	23	23	56.2	27.7	6.6
2913-9H20	87-309H3 x 0913-9	24	23	6.4	83.3	5.4
2915-4H20	87-309H3 x 0915-4	23	24	13.6	69.0	5.4
2915-7H20	87-309H3 x 0915-7	25	24	26.7	56.6	5.4
2915-46H20	87-309H3 x 0915-46	19	19	3.2	80.6	5.2

TEST 2093. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1993

(cont.)

Variety	Description[1]	Stand Count/ Plot	Harv. Count/ Plot	Erwinia Reaction[2] DI	Erwinia Reaction[2] % Resistant	P.M. Avg.[3]
Block 5 (cont.)						
N203H15	1915aa x N103 (C603)	23	22	34.2	34.7	5.7
2859H15	1915aa x 1859,1859R	24	23	24.7	57.5	4.6
2867H15	1915aa x 1867,1867R	19	18	20.5	64.2	4.6
2865H15	1915aa x 1865,1865-#	21	22	13.4	71.2	4.4
2865H13	1913aa x 1865,1865-#	22	21	43.8	38.9	4.8
Reciprocal Hybrids, MMaa x mm Tester						
2865H43- 4	C911- 4aa x RZM 1865-#	23	22	16.5	70.3	4.9
2865H43-12	C911-12aa x RZM 1865-#	23	21	23.8	62.9	4.4
2865H43-14	C911-14aa x RZM 1865-#	26	25	32.1	55.9	5.4
Block 6						
2865H43-50	C911-50aa x RZM 1865-#	25	24	14.3	72.2	5.3
E840	Inc. E440 (C40)	27	25	99.8	0.0	8.1
US H11	L113401	27	27	5.2	81.6	6.0
2865H45- 5	1913- 5aa x RZM 1865-#	27	25	16.6	71.3	5.2
2865H45-18	1913-18aa x RZM 1865-#	26	22	11.6	78.7	5.1
2865H45-22	1913-22aa x RZM 1865-#	27	25	7.5	87.8	3.9
2865H45-25	1913-25aa x RZM 1865-#	27	24	8.0	80.4	4.7
2865H46- 1	0911- 1aa x RZM 1865-#	24	24	31.2	53.4	4.2
2865H46-4(B)	0911-4(B)aa x RZM 1865-#	25	23	17.6	66.0	4.8
2865H46-24	0911-24aa x RZM 1865-#	25	26	65.2	21.4	5.8
2865H47-6	0913- 6aa x RZM 1865-#	25	26	14.1	73.1	5.3
2865H47-9	0913- 9aa x RZM 1865-#	26	26	14.7	76.8	5.0
2865H48-1	0915- 1aa x RZM 1865-#	25	22	29.2	56.1	4.7
2865H48-4	0915- 4aa x RZM 1865-#	23	22	9.8	77.3	4.3
2865H48-6	0915- 6aa x RZM 1865-#	27	27	9.7	80.8	5.2
2865H48-7	0915- 7aa x RZM 1865-#	27	27	20.0	67.4	4.8

TEST 2093. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1993

(cont.)

Variety	Description[1]	Stand Count/ Plot	Harv. Count/ Plot	Erwinia Reaction[2] DI	Erwinia Reaction[2] % Resistant	P.M. Avg.[3]
Block 7						
2865H48-16	0915-16aa x RZM 1865-#	25	25	24.0	62.2	4.1
2865H48-22	0915-22aa x RZM 1865-#	26	26	17.3	67.3	4.4
2865H48-23	0915-23aa x RZM 1865-#	24	24	12.2	70.5	4.2
2865H48-24	0915-24aa x RZM 1865-#	25	24	12.6	80.1	4.0
2865H48-27	0915-27aa x RZM 1865-#	25	23	30.1	54.0	4.4
2865H48-34	0915-34aa x RZM 1865-#	24	23	18.4	69.5	5.3
2865H48-46	0915-46aa x RZM 1865-#	24	22	19.1	68.6	5.0
2915H65	1865aa x 1913,1915	24	22	42.7	37.4	5.8
Population Hybrids						
2915H58	C859Raa x 1913,1915	24	24	20.7	58.3	4.8
2915H68	1867Raa x 1913,1915	24	22	29.0	49.2	5.0
2915H90	C790aa x 1913,1915	24	22	26.3	53.6	3.8
R280H90	C790aa x R080	21	21	25.8	60.7	3.3
R280H91	C790HO x R080	24	24	28.7	51.5	4.0
R280H93	C890aa x R080	23	22	35.5	49.9	4.7
R280H58	C859Raa x R080	21	21	36.1	45.0	5.0
R280H65	1865aa x R080	26	24	43.0	46.8	4.7
Topcross Hybrids						
Block 8						
R280H66	1865-#(C)aa x R080	25	24	28.9	53.6	6.6
R280H68	1867Raa x R080	23	23	31.5	50.4	4.8
R280H64	1864aa x R080	23	21	41.7	46.0	5.1
R280H62- 1	0864- 1aa x R080	23	22	29.8	53.5	4.2
R280H62- 5	0864- 5aa x R080	22	19	49.6	34.9	4.0
R280H62- 8	0864- 8aa x R080	25	23	20.9	63.2	4.2
R280H62-14	0864-14aa x R080	25	25	34.3	57.3	4.3
R280H62-19	0864-19aa x R080	24	20	45.0	44.1	4.2

TEST 2093. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1993

(cont.)

Variety	Description[1]	Stand Count/ Plot	Harv. Count/ Plot	Erwinia Reaction[2] DI	Erwinia Reaction[2] % Resistant	P.M. Avg.[3]
Block 8 (cont.)						
R280H62-25	0864-25aa x R080	21	20	38.1	43.4	4.2
R280H62-28	0864-28aa x R080	21	21	22.6	52.9	4.9
R280H62-34	0864-34aa x R080	24	24	32.8	50.8	4.2
R280H62-40	0864-40aa x R080	23	23	36.0	40.7	4.7
R280H63	0864HO x R080	23	23	25.5	59.6	4.4
US H11	L113401	26	23	3.5	85.7	5.4
E840	Inc. E440, E640 (C40)	26	27	99.9	0.0	7.8
E840H8	F82-546H3 x C40	21	21	65.6	24.4	5.7
Block 9 monogerm, self-fertile lines (F_1 CMS Hybrids)						
F82-546H3	82460, C562HO x C546	26	26	13.1	71.5	7.2
87-309H3	87671, C562HO x C309	23	24	28.1	37.6	7.4
87-309H37	87242, C306HO x C309	25	22	50.5	29.1	6.7
88-790-68H37	88191, C306HO x C790-68	24	21	60.2	12.6	4.0
88-790-68H26	88189, C309HO x C790-68	25	25	55.6	30.0	6.6
F92-790-6H26	921186, C309HO x C790-6	26	27	22.1	53.3	6.0
F92-790-15H26	921191, C309HO x C790-15	25	24	40.4	37.1	5.1
F92-790-54H26	921196, C309HO x C790-54	26	25	30.3	55.2	5.9
F92-790-6H39	921187, C762-17CMS x C790-6	23	25	47.3	22.7	4.0
F92-790-15H39	921192, C762-17CMS x C790-15	27	26	67.0	13.8	3.6
F92-790-54H39	921197, C762-17CMS x C790-54	25	25	63.0	17.4	3.6
88-790-68H92	88190, C796-22CMS x C790-68	24	25	30.8	51.6	4.3
F92-790-6H97	921188, C796-43CMS x C790-6	26	21	25.5	57.4	4.8
F92-790-15H97	921193, C796-43CMS x C790-15	25	23	25.2	54.9	4.7
F92-790-54H97	921198, C796-43CMS x C790-54	26	25	25.2	65.8	4.3
F82-546H3	82460, C562HO x C546	25	22	19.5	65.5	6.7

TEST 2093. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1993

(cont.)

Variety	Description[1]	Stand Count/ Plot	Harv. Count/ Plot	Erwinia Reaction[2] DI	Erwinia Reaction[2] % Resistant	P.M. Avg.[3]
Monogerm, Self-fertile lines						
Block 10						
F82-546	82372, C546	24	24	3.9	86.0	6.4
87-309	87672, C309	24	22	17.3	62.8	7.1
88-790-68	88192, C790-68	22	19	37.9	37.9	3.2
88-790-68CMS	88187, C790-68CMS	21	20	52.0	23.0	3.2
F92-790-6	921189, C790-6	22	16	28.5	56.5	2.8
F92-790-6CMS	921185, C790-6CMS	24	21	43.5	30.1	3.4
F92-790-15	921194, C790-15	23	22	27.4	43.1	2.8
F92-790-15CMS	921190, C790-15CMS	23	22	57.0	16.8	3.3
F92-790-54	921199, C790-54	24	23	34.4	51.3	2.7
F92-790-54CMS	921195, C790-54CMS	22	21	48.7	32.2	2.8
89-762-17	89121, C762-17	22	22	90.0	5.9	3.8
91-762-17	10/22/91, C762-17	19	19	97.6	0.0	3.8
91-767-46	10/22/91, C767-46	24	23	4.7	86.8	6.0
F82-562	82196, C562	20	20	66.1	13.4	6.8
E840	Inc. E440, E640 (C40)	24	25	98.5	1.4	7.1
US H11	L113401	24	22	7.6	81.9	5.9
Mean		23.9	23.0	34.0	50.1	5.0
LSD (.05)		3.1	3.9	14.0	17.9	1.2
C.V. (%)		8.2	10.4	25.6	22.3	14.8
F value		2.9**	2.2**	19.4**	11.2**	6.6**

TEST 2093. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS AND MONOGERM SELF-FERTILE LINES, SALINAS, CA., 1993

(cont.)

Variety	Description[1]	Stand Count/ Plot	Harv. Count/ Plot	Erwinia Reaction[2] DI	Erwinia Reaction[2] % Resistant	P.M. Avg.[3]

Tests 2093 and 2193 appeared to be good tests to evaluate Erwinia root rot. Mixed inoculum of four isolates was used. The most virulent and aggressive one appeared to be the Imperial Valley isolate from 1991. Based upon the checks, these tests should be reliable for evaluating reaction to Erwinia.

[1]See Test 2193 for more detailed descriptions of components of hybrids and releases.

[2]Erwinia root rot: DI = average % rot per root at harvest; % resistant = percentage of roots scored 0 and 1% rotted.

[3]Powdery mildew not controlled. Scored on a scale of 0 to 9, where 9 = 90-100% of mature leaf area covered by visible mildew. Powdery mildew scored on 08/24, 09/02, & 09/16/93.

TEST 2193. ERWINIA POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1993

160 entries x 3 replications
1-row plots, 18 ft. long

Planted: April 20, 1993
E.c.b. Inoc.: July 15, 1993
Scored: October 5, 1993

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia Reaction DI	Erwinia Reaction % Resistant	P.M. Avg.
Block 1						
MM,O.P. lines						
US H11	L113401	22	18	4.5	82.9	5.0
E840	Inc. E440, E640 (C40)	25	22	97.4	0.0	7.7
E840H72	83-718HO x C40	25	24	90.8	3.2	8.0
E840H8	F82-546H3 x C40	21	23	45.1	35.8	6.7
U86-37	C37, 86443	22	21	3.5	86.1	4.3
R279	RZM R079 (C37Rz)	21	22	11.2	73.9	4.5
R279Y	RZM-BYV-ER R079	22	20	8.7	80.1	4.2
R279R2	RZM 1204-#(C)	24	25	8.9	83.7	5.3
R128	RZM 0271-# (C28)	17	17	24.6	58.5	4.5
R228	RZM 1202-#(C)	25	26	18.5	56.9	4.7
R130	RZM R030	26	28	11.7	84.4	2.8
R230	RZM R130	26	25	13.0	76.3	3.2
R221	RZM R121	23	21	13.4	78.4	4.2
Y954	Inc. Y854	23	23	6.6	90.2	2.8
Y054	BYR-ER-PMR Y854	23	22	3.8	95.6	2.7
R080	RZM R980	25	24	24.6	66.2	4.3
Block 2						
R280 (SpMR)	RZM R080	18	19	26.1	56.4	3.8
R280	RZM R080	25	25	25.1	62.6	4.0
R280Y	RZM-BYV-ER R080	23	24	21.7	69.4	3.7
R280- 1	Inc. R080- 1	29	29	19.5	68.7	4.2
-13	Inc. R080-13	21	22	6.2	87.9	3.2
-28	Inc. R080-28	25	25	7.9	86.7	2.5
-35	Inc. R080-35	25	25	54.5	36.3	2.5
-45	Inc. R080-45	28	28	8.3	79.5	2.0

TEST 2193. ERWINIA POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1993
(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia Reaction DI	Erwinia Reaction % Resistant	P.M. Avg.
Block 2 (cont.)						
R280-56	Inc. R080-56	22	23	5.3	84.5	1.5
-79	Inc. R080-79	23	22	17.3	70.7	1.8
-80	Inc. R080-80	24	23	5.8	89.9	2.3
R122R3	RZM R022R2	26	24	57.5	24.2	5.5
R222R4	RZM R122R3	26	26	44.2	40.7	6.2
R122Y2	BYR R922Y	24	22	37.4	44.3	3.5
R070	Inc. R971-R980	24	22	24.0	60.7	3.5
R270Y	RZM-BYV-ER R070	26	25	20.3	59.5	3.7
Block 3						
U86-46/2	C46/2, 86342	22	22	6.2	86.5	2.2
Y846	Inc. Y746	22	21	5.9	86.2	1.2
R278 (SpMR)	RZM R078	23	22	22.4	63.8	2.3
R278	RZM R078 (C46Rz)	24	24	19.4	71.3	2.7
R278Y	RZM-BYV-ER R078	19	20	28.6	54.5	3.3
F86-31/6	86263, Inc. C31/6	23	22	17.4	66.6	1.3
R276 (SpMR)	RZM R076	23	22	21.9	67.7	2.8
R276	RZM R076 (C31/6Rz)	24	24	26.2	56.2	2.7
R276Y	RZM-BYV-ER R076	21	18	25.5	60.0	4.3
Y231-43	Inc. Y131-43 (C31-43)	24	23	0.5	97.1	2.5
R276-43	RZM R176-43	26	25	17.0	70.8	1.2
R281-43	Y131-43 x RZM R176-43,-89	18	18	4.9	83.2	2.2
Y231-89	Inc. Y131-89 (C31-89)	26	28	15.2	74.3	2.5
R276-89	RZM R176-89	25	24	18.8	65.3	2.2
R281-89	Y131-89 x R176-43,-89	20	20	15.9	78.3	1.5
R282	Inc. R176-43,-89	23	24	27.8	60.1	2.8

TEST 2193. ERWINIA POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1993
(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia Reaction DI	Erwinia Reaction % Resistant	P.M. Avg.
Block 4						
E840	Inc. E440, E640 (C40)	25	26	98.3	1.4	7.5
Y141	BYR Y841 (C91)	25	24	11.5	71.6	2.3
Y148	BYR Y948 (C93)	25	26	3.9	89.7	3.0
Y049	BYR-ER-PMR Y849 (C49)	26	25	2.2	95.8	0.3
Y156	BYR Y956	18	20	16.4	67.9	2.2
Y139	BYR Y939 (C39)	24	24	10.5	81.2	1.8
R039C5	Inc. R939C5 (C39R5)	23	24	22.5	61.1	0.8
R239C8	RZM R139C7	26	24	38.9	52.5	1.8
Y147	BYR Y947 (C47)	18	19	5.2	82.1	3.3
R047C5	Inc. R947C5 (C47R5)	21	21	7.2	83.8	2.8
R247C8	RZM R147C7	26	22	0.4	98.5	4.2
R204	RZM R104	25	24	1.2	90.2	3.5
R232	RZM 1201-#(C)	23	20	9.6	78.5	4.0
P201	PMR 1211,...,1216	25	24	5.6	91.5	3.8
P202	PMR 1217,...,1224	23	22	5.1	83.4	3.3
U86-37	C37, 86443	23	22	8.9	79.1	4.7
Block 5						
MM,S^f,A:aa lines and populations						
R207	RZM R107	24	23	18.5	66.0	4.5
R208	RZM R108	24	22	30.5	57.7	3.7
Z220	RZM Z120,Z122,Z124	23	23	24.8	68.7	4.0
Z230	RZM Z120,-4aa x 1913,1915	22	22	14.9	71.4	3.5
1905	BYR 9905 (A,aa)	18	18	5.0	87.8	2.8
2916	1905aa x 1913,1915	22	21	11.9	81.1	2.8
5747	4747aa x A	24	24	3.8	88.9	4.3
2910	Inc. 1210(C)	24	25	5.1	88.0	4.8
R129	RZM 0281-#	21	22	11.7	80.7	5.0
R229	Inc. 1206(C)	21	20	12.7	67.4	5.2

TEST 2193. ERWINIA POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1993
(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia Reaction DI	Erwinia Reaction % Resistant	P.M. Avg.
Block 5						
MM,S^f,A:aa lines and populations (cont.)						
R229-4-1	Inc. R029-4-1	23	24	20.2	57.7	4.2
R233	Inc. 1205(C)	24	23	3.0	91.7	4.7
2910-1-1	Inc. 1910-1-1	22	21	40.9	30.8	5.8
2910-12-1	Inc. 1910-12-1	22	21	3.0	79.1	3.7
2914	RZM 1914	23	21	6.0	83.5	2.5
E840	Inc. E440, E640 (C40)	23	22	100.0	0.0	8.5
Block 6						
US H11	L113401	24	19	12.5	67.0	5.8
9903	YR-ER-PMR 7903 (A,aa)	25	25	3.6	86.6	3.7
8909	7909aa x A	25	27	3.8	91.1	2.8
9911	8911aa x A	26	26	16.0	76.7	3.0
0911	9911aa x A	25	25	12.2	80.0	3.2
2911Y	RZM-BYV-ER 0911	22	22	8.0	77.5	3.3
2911- 4	RZM 1911- 4 (C911- 4)	26	28	1.4	96.3	3.0
2911-12	RZM 1911-12 (C911-12)	25	25	15.2	73.4	3.8
2911-14	RZM 1911-14 (C911-14)	24	22	22.6	61.3	3.2
2911-50	RZM 1911-50 (C911-50)	24	23	11.3	78.0	3.0
US H11	L113401	25	21	4.8	84.0	6.2
E840	Inc. E440, E640 (C40)	24	22	99.5	0.0	8.2
E840H72	83-718HO x C40	26	25	96.3	0.0	8.3
E840H8	F82-546H3 x C40	21	22	50.0	40.0	6.7
0909-34	Inc. 8909A-34 (C909-34)	23	22	11.4	82.0	2.3
0909-37	Inc. 8909A-37 (C909-37)	26	25	9.6	82.8	1.5

TEST 2193. ERWINIA POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1993
(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia Reaction DI	Erwinia Reaction % Resistant	P.M. Avg.
Block 7						
2913	RZM 1913 (A,aa)	16	17	28.5	61.6	3.7
2913Y	RZM-BYV-ER 0913	23	24	3.6	90.2	2.0
2913- 5	RZM 1913- 5	23	22	4.5	88.1	2.5
2913-18	RZM 1913-18	23	22	0.3	95.6	1.8
2913-22	RZM 1913-22	20	23	7.1	81.8	2.0
2913-25	RZM 1913-25	21	22	1.6	95.4	2.3
2915	RZM 1915-#(C) (A,aa)	24	23	7.5	79.7	2.2
2915Y	RZM-BYV-ER 0915	23	23	4.2	84.9	2.7
2915 Sp	RZM 1915-#,1913-#aa x A	21	21	14.6	71.0	2.7
0911-1	9911aa x 9911,9911H49	24	22	9.2	72.8	1.7
0911-4(B)	9911aa x 9911,9911H49	23	21	4.1	88.2	2.8
2911-24	Inc. 0911-24 (A,aa)	25	25	43.5	37.7	4.7
0913-6	9911H49aa x 9911,9911H49	23	22	6.9	91.0	3.8
2913-9	Inc. 0913-9 (A,aa)	21	22	0.2	97.0	2.0
0915-1	9903aa x 9911,9911H49	21	21	2.6	92.7	3.8
2915-4	Inc. 0915-4 (A,aa)	23	22	12.5	75.5	4.2
Block 8						
0915-6	9903aa x 9911,9911H49	23	23	1.9	93.9	3.2
2915-7	Inc. 0915-7 (A,aa)	26	25	3.8	89.4	2.5
E840	Inc. E440, E640 (C40)	25	25	96.2	2.4	7.7
0915-22	9903aa x 9911,9911H49	23	24	0.8	95.8	1.8
0915-23	9903aa x 9911,9911H49	22	22	1.8	92.5	0.8
0915-24	9903aa x 9911,9911H49	24	24	1.3	92.9	2.5
0915-27	9903aa x 9911,9911H49	20	21	9.2	79.7	2.3
0915-34	9903aa x 9911,9911H49	21	21	2.7	90.7	3.3
2915-46	Inc. 0915-46 (A,aa)	20	21	0.0	100.0	1.7
0915(C)	9903aa x 9911,9911H49	24	23	11.6	78.4	3.2
1915	RZM 0915 (A,aa)	24	23	7.6	84.1	3.5

TEST 2193. ERWINIA POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1993
(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia Reaction DI	Erwinia Reaction % Resistant	P.M. Avg.
monogerm, S^f,A:aa populations						
0790	8790-S_1(C5)aa x A (C790)	28	27	40.9	35.2	4.0
2890	0790mmaa x 1890,RZM 1890	19	19	40.7	31.7	4.3
2890HO	0790HO x 1890,RZM 1890	23	23	40.4	30.1	5.0
2891m	1890mmaa x A	22	22	43.4	39.0	5.2
2888m	Composite B aa x (C)A&B	24	23	54.9	21.4	5.5
Block 9						
2889m	Composite C aa x (C)A&B	16	17	43.4	32.7	5.5
E840	Inc. E440, E640 (C40)	24	23	97.6	1.3	7.8
2859	RZM 1859	25	25	51.1	36.2	5.3
2859R	RZM 1859R	24	23	66.7	17.1	5.7
2859m Sp	1859,1859Raa x A (C859)	20	20	63.3	26.8	5.8
2859M Sp	1859,1859Raa x A	22	23	67.6	17.9	6.5
2859m HO	0859HO x 1859,1859R (C859CMS)	23	23	64.8	16.0	5.5
2864	RZM 1864	25	25	70.2	18.4	6.0
1867	NB 9867m (A,aa)	19	18	51.0	34.7	5.3
2867	RZM 1867 (A,aa)	22	21	67.5	16.7	5.0
2867m Sp	1867,1867Raa x A	21	20	33.7	44.7	5.2
F82-546H3	82460 (C562CMS x C546)	26	24	19.1	61.7	5.8
2866	RZM 1866 (A,aa)	19	20	54.0	34.1	5.7
2865	RZM 1865-#(C) (A,aa)	23	22	54.0	24.5	5.3
2865m Sp	RZM 1865-#,1865aa x A	21	21	52.9	33.0	5.2
2865HO	87-309CMS x 1865,1865-#	23	21	56.8	23.9	6.0
Block 10						
NR Lines and Selections						
N801(A)	Inc. B883	18	19	73.5	17.2	6.7
N203 Sp	Inc. N103 (C603)	22	21	54.8	25.1	8.0
N203-1 Sp	Inc. N103-1 (C603-1)	23	23	98.6	0.0	8.0
E840	Inc. E440, E640 (C40)	25	24	98.3	0.0	8.0

TEST 2193. ERWINIA POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1993
(cont.)

Variety	Description	Harv. Count/ Plot	Stand Count/ Plot	Erwinia Reaction DI	Erwinia Reaction % Resistant	P.M. Avg.
Block 10 (cont.)						
NR Lines and Selections (cont.)						
N204	Inc. 1226-1 (C604)	19	18	88.0	8.3	6.3
N205	Inc. 1227-3 (C605)	23	21	62.1	20.5	5.3
N206	Inc. 1227-7 (C606)	24	22	39.1	41.2	6.3
N207	Inc. 1227-12 (C607)	19	18	12.6	77.1	5.3
N244	NR-RZM N144-1-#(C)	22	20	30.0	61.4	6.0
N254-#-#(C)	1915aa x N144-#	22	20	5.1	85.1	4.3
N203H15	1915aa x N103,N103-1	26	24	27.6	56.5	5.8
N203H18	790-68H23 x N103,N103-1	23	22	74.7	10.1	8.2
N203H20	309H3 x N103,N103-1	26	24	75.9	7.3	8.0
N203H89	790-68CMS x N103,N103-1	24	22	85.3	6.0	8.0
E840	Inc. E440, E640 (C40)	24	22	99.8	0.0	7.8
US H11	L113401	25	21	13.4	74.8	5.5
Mean		23.0	22.5	27.1	61.8	4.1
LSD (.05)		5.9	6.1	13.6	17.5	1.5
C.V. (%)		16.0	16.8	31.3	17.6	23.2
F value		1.2NS	1.1NS	32.9**	21.4**	11.8**

Note: Erwinia tests were inoculated with four isolates. Tests by Dr. Alice Pilgeram suggest that most infection was due to a 1991 isolate from the Imperial Valley. Based upon experience with Erwinia tests over the past 20 years, these are particularly good trials for evaluating differences.

TEST 1893. CODED POWDERY MILDEW TEST,
SALINAS, CA., 1993

192 entries x 6 reps, RCB
1-row plots, ft. long

Planted: March 9, 1993

Entry No.	Variety	Co.	Beets/ Plot No.	Powdery Mildew Score 8/06	8/10	8/24	8/31	9/16	Mean
PM- 3	H90293	Spreck	12.7	0.8	0.7	2.2	2.7	3.3	1.9
- 5	H92528	Spreck	12.8	2.7	3.2	4.7	6.2	7.0	4.7
- 7	H89349	Spreck	12.8	1.0	3.0	4.0	5.2	6.2	3.9
- 10	H92661	Spreck	13.0	1.3	1.8	3.8	4.7	6.3	3.6
- 18	SS-502	Spreck	13.0	1.7	2.0	3.2	5.0	6.5	3.7
- 19	H90663	Spreck	13.3	1.3	2.5	4.0	5.3	7.0	4.0
- 23	SS-595R	Spreck	12.8	1.8	2.7	4.0	5.2	6.8	4.1
- 26	H88335	Spreck	13.3	1.2	2.3	3.0	4.5	5.2	3.2
- 29	H88200	Spreck	13.5	0.2	0.7	1.7	3.3	4.2	2.0
- 34	SS-NB2	Spreck	13.7	1.3	2.2	4.0	5.5	7.0	4.0
- 41	SS-377	Spreck	12.2	1.2	2.8	3.2	4.0	5.5	3.3
- 42	H91667	Spreck	11.5	0.8	2.3	3.5	4.5	5.7	3.4
- 47	H89272	Spreck	12.8	1.2	3.0	4.3	6.2	7.8	4.5
- 49	SS-VY1	Spreck	12.2	0.7	1.5	2.8	3.8	4.7	2.7
- 51	H92660	Spreck	12.3	1.2	2.5	3.2	3.8	5.0	3.1
- 52	H92632	Spreck	12.7	0.7	3.2	4.0	4.3	6.2	3.7
- 54	H90376	Spreck	13.2	0.7	1.7	2.7	4.5	5.7	3.0
- 55	SS-334	Spreck	12.7	1.7	3.2	3.3	5.3	6.7	4.0
- 56	H89401	Spreck	13.5	1.2	1.3	2.7	4.0	5.5	2.9
- 60	SS-NB5	Spreck	12.0	0.8	2.0	3.7	5.2	6.3	3.6
- 61	H90636	Spreck	12.8	1.3	3.0	4.5	6.2	6.7	4.3
- 66	H90586	Spreck	13.3	1.0	2.3	3.5	5.0	6.3	3.6
- 69	SS-781R	Spreck	11.7	1.0	2.2	4.0	5.2	6.0	3.7
- 70	SS-270	Spreck	11.8	1.0	2.2	3.2	5.0	5.3	3.3
- 74	H90448	Spreck	12.0	0.5	1.7	2.5	4.0	4.8	2.7
- 76	SS-287R	Spreck	12.3	0.8	2.7	3.5	4.7	5.8	3.5
- 83	H90273	Spreck	12.5	0.8	2.5	4.0	4.7	5.2	3.4
- 89	SS-Y1	Spreck	13.2	1.2	1.3	2.7	4.3	5.5	3.0
- 92	SS-289R	Spreck	13.0	2.8	3.5	4.7	6.7	7.5	5.0
- 94	H89303	Spreck	13.3	1.0	2.5	3.7	5.8	7.0	4.0
- 99	SS-231	Spreck	12.8	1.2	2.7	3.0	4.3	6.5	3.5
-102	SS-NB2R	Spreck	11.7	1.8	2.7	3.8	5.8	7.7	4.4
-105	H90556	Spreck	11.7	1.0	2.5	3.8	5.2	6.5	3.8
-109	H91598	Spreck	13.3	0.3	1.8	3.3	5.0	5.7	3.2
-110	SS-596R	Spreck	12.5	0.7	2.2	3.0	4.5	5.7	3.2

TEST 1893. CODED POWDERY MILDEW TEST,
SALINAS, CA., 1993

(cont.)

Entry No.	Variety	Co.	Beets/ Plot No.	Powdery Mildew Score 8/06	8/10	8/24	8/31	9/16	Mean
PM-112	H89299	Spreck	12.5	0.7	2.2	3.5	4.8	6.3	3.5
-120	SS-IV1	Spreck	13.3	0.7	2.2	3.5	4.5	6.3	3.4
-123	SS-242	Spreck	13.5	0.5	2.3	4.0	6.0	6.8	3.9
-126	SS-593R	Spreck	12.2	0.8	2.8	3.5	5.3	6.8	3.9
-129	H92566	Spreck	13.2	2.0	3.3	5.2	7.0	8.5	5.2
-134	H91570	Spreck	12.7	1.7	2.3	4.2	5.8	6.7	4.1
-137	H91706	Spreck	13.2	0.7	2.3	1.8	4.0	6.0	3.0
-141	SS-790R	Spreck	12.5	0.8	2.8	3.8	5.2	6.5	3.8
-146	SS-293R	Spreck	12.2	0.3	2.7	3.2	4.3	5.2	3.1
-151	H92535	Spreck	13.5	2.0	3.2	3.7	5.5	6.0	4.1
-152	H90631	Spreck	12.8	1.3	3.0	3.8	5.2	6.0	3.9
-153	SS-NB3	Spreck	12.2	2.0	3.5	4.5	5.8	7.5	4.7
-155	H88313	Spreck	13.2	1.0	2.7	4.0	5.2	6.5	3.9
-156	SS-246	Spreck	13.3	1.0	1.3	2.7	4.3	6.0	3.1
-161	H90272	Spreck	13.2	1.2	2.7	3.8	4.8	6.5	3.8
-166	SS-334R	Spreck	11.8	1.3	3.2	5.0	6.3	7.3	4.6
-172	H91572	Spreck	12.2	0.7	1.2	3.0	4.5	4.8	2.8
-173	SS-181	Spreck	12.7	0.3	1.5	3.0	4.3	5.7	3.0
-175	H90771	Spreck	10.5	0.7	1.2	3.2	4.3	5.5	3.0
PM- 1	9BG6371	Beta	12.2	1.0	1.8	3.3	3.7	5.5	3.1
- 9	Beta 4823	Beta	13.2	2.5	3.3	5.0	6.5	6.7	4.8
- 14	2BG6338	Beta	13.3	0.5	1.2	1.8	3.5	5.2	2.4
- 17	Beta 4757	Beta	12.8	0.3	1.8	1.7	2.5	4.8	2.2
- 24	2BG6101	Beta	13.7	1.3	2.5	4.7	5.3	6.7	4.1
- 30	2BX6218	Beta	12.7	0.0	0.5	1.5	3.0	4.5	1.9
- 31	1BG6541	Beta	13.7	0.8	2.5	3.8	5.5	6.8	3.9
- 32	0BG6350	Beta	13.3	0.2	1.2	1.2	2.7	5.0	2.0
- 33	2BG6092	Beta	11.0	0.3	2.3	3.3	4.5	5.7	3.2
- 37	1J5087	Beta	13.2	1.0	1.7	2.7	4.5	5.3	3.0
- 39	0BG6108	Beta	13.0	0.2	1.2	2.5	4.2	5.0	2.6
- 40	0BG6134	Beta	12.8	0.3	1.2	2.5	3.7	5.5	2.6
- 43	0BG6147	Beta	12.3	1.0	2.0	3.8	4.8	6.5	3.6
- 45	0BG6333	Beta	11.7	0.2	1.3	3.2	4.3	5.8	3.0
- 48	1BG6131	Beta	13.0	0.3	1.0	2.2	3.2	5.0	2.3
- 58	2BG6249	Beta	6.5	0.3	0.2	0.5	1.7	3.2	1.2
- 59	Beta 4454	Beta	13.5	0.5	0.2	1.0	2.8	3.7	1.6
- 62	0BG6109	Beta	13.8	0.8	1.7	3.0	4.8	5.7	3.2
- 64	Beta 4587	Beta	13.2	1.3	2.3	3.7	5.0	7.0	3.9
- 68	0BG6217	Beta	14.0	0.8	1.8	3.0	4.0	5.0	2.9

TEST 1893. CODED POWDERY MILDEW TEST,
SALINAS, CA., 1993

(cont.)

Entry No.	Variety	Co.	Beets/ Plot No.	Powdery Mildew Score 8/06	8/10	8/24	8/31	9/16	Mean
PM- 72	0BG6182	Beta	13.5	0.7	2.7	4.0	5.0	6.0	3.7
- 84	0BG6392	Beta	11.8	0.3	1.5	3.5	4.5	5.3	3.0
- 88	2BG6067	Beta	12.5	0.2	1.5	2.3	3.3	5.0	2.5
- 96	2BG6345	Beta	6.0	0.2	1.0	1.8	3.3	5.2	2.3
- 97	2BG6079	Beta	12.3	0.5	1.8	3.2	4.5	5.3	3.1
-100	2BG6066	Beta	13.5	0.5	2.3	2.8	4.7	5.5	3.2
-107	9BG6272	Beta	13.2	0.5	2.0	3.2	5.8	7.2	3.7
-117	Beta 4284	Beta	14.0	2.3	3.2	4.8	6.5	7.5	4.9
-127	1BG6585	Beta	13.2	1.3	2.0	4.0	4.7	6.3	3.7
-131	0BG6560	Beta	13.0	0.3	1.3	2.5	4.0	5.7	2.8
-136	2BG6068	Beta	13.0	0.2	1.5	2.3	3.5	4.8	2.5
-138	2BG6069	Beta	13.3	1.2	3.0	3.8	5.8	7.0	4.2
-142	0BG6430	Beta	12.2	0.2	1.0	2.5	3.5	5.2	2.5
-143	0BG6450	Beta	12.7	1.3	1.3	3.5	5.5	7.7	3.9
-144	Beta 4783	Beta	13.8	0.2	0.3	2.3	3.5	5.5	2.4
-149	Beta 4452	Beta	12.5	0.0	0.2	1.2	3.0	4.2	1.7
-159	9BG6346	Beta	11.7	1.2	2.0	3.5	5.0	6.5	3.6
-160	2BG6250	Beta	11.5	0.3	2.3	3.3	4.7	5.5	3.2
-163	9BG6380	Beta	12.7	0.0	0.7	1.5	3.2	4.3	1.9
-165	Beta 4581	Beta	12.8	0.7	1.8	3.0	3.8	4.8	2.8
-170	0BG6178	Beta	13.7	2.7	3.5	4.8	6.2	7.7	5.0
-171	2BG6100	Beta	13.0	1.3	2.8	3.7	5.0	6.5	3.9
-174	0BG6330	Beta	11.7	0.0	1.0	2.0	3.2	5.2	2.3
PM- 2	93HX9	Holly	12.5	2.5	3.0	5.0	6.3	7.5	4.9
- 4	92HX2	Holly	12.3	0.3	2.7	3.2	4.7	5.0	3.2
- 6	90C 68-03	Holly	12.3	1.3	3.5	4.7	6.0	6.3	4.4
- 12	93HX8	Holly	13.2	1.5	2.2	4.0	5.2	6.5	3.9
- 13	HH77	Holly	12.5	0.8	2.2	4.7	5.7	6.3	3.9
- 16	90C 64-05	Holly	11.3	1.5	3.7	4.3	6.0	7.5	4.6
- 20	89C 58-03	Holly	11.5	1.0	3.0	4.3	5.5	6.5	4.1
- 25	93HX12	Holly	12.3	1.3	3.2	4.7	5.7	7.0	4.4
- 27	93HX11	Holly	12.5	0.3	2.8	3.8	5.5	6.7	3.8
- 28	USC-1	Holly	12.2	0.5	1.3	3.2	4.2	5.8	3.0
- 38	93HX23	Holly	11.8	1.3	2.8	4.2	5.7	6.7	4.1
- 44	93HX1	Holly	11.5	0.3	2.0	3.3	4.5	5.3	3.1
- 53	93HX6	Holly	12.2	0.5	1.2	3.2	4.8	6.5	3.2
- 57	93HX7	Holly	12.0	0.5	2.3	4.0	5.3	6.2	3.7
- 63	93HX2	Holly	12.7	0.3	1.8	3.7	5.3	6.8	3.6

TEST 1893. CODED POWDERY MILDEW TEST,
SALINAS, CA., 1993

(cont.)

Entry No.	Variety	Co.	Beets/ Plot No.	Powdery Mildew Score 8/06	8/10	8/24	8/31	9/16	Mean
PM- 65	90-1459-0112	Holly	13.3	1.7	2.0	4.2	5.3	6.2	3.9
- 67	HH-84	Holly	13.3	0.7	2.8	4.0	5.5	6.5	3.9
- 73	92HX1	Holly	12.2	1.0	2.5	3.8	5.3	6.3	3.8
- 75	HH-45	Holly	13.5	1.3	2.7	3.7	5.0	6.0	3.7
- 78	Rhizosen	Holly	12.8	1.3	3.2	5.7	7.3	7.8	5.1
- 80	90-88C11-09	Holly	10.8	2.7	3.8	5.8	7.7	8.7	5.7
- 81	93HX5	Holly	12.8	1.2	3.2	4.5	6.2	6.8	4.4
- 82	HH-66	Holly	12.5	1.3	2.8	5.0	6.5	7.5	4.6
- 86	90-1459-0188	Holly	12.7	0.3	2.0	3.8	5.0	6.0	3.4
- 87	86-1459-026	Holly	13.8	1.0	3.0	3.8	4.7	6.0	3.7
- 91	93HX10	Holly	12.5	1.2	2.7	3.5	5.7	7.0	4.0
- 93	91C 143-07	Holly	12.8	1.2	2.0	3.5	4.8	5.5	3.4
-101	HH-46	Holly	12.5	1.5	3.2	4.0	5.5	7.5	4.3
-104	HH-38	Holly	12.8	0.3	1.5	2.8	4.2	5.7	2.9
-108	90-87C34-06	Holly	11.0	1.7	3.7	5.5	7.0	8.0	5.2
-111	90C 68-04	Holly	12.0	0.2	2.2	3.7	4.7	5.7	3.3
-113	90C 63-010	Holly	12.7	0.8	3.2	4.2	5.7	6.7	4.1
-115	91-89C58-06	Holly	8.5	1.7	3.3	4.3	5.3	6.3	4.2
-118	93HX22	Holly	12.8	1.0	3.0	4.7	5.5	6.7	4.2
-119	Rhizoguard	Holly	11.2	1.0	3.0	4.5	5.3	6.8	4.1
-121	HH-55	Holly	13.2	0.2	1.5	2.8	4.0	4.8	2.7
-122	Rhizosen CT	Holly	12.5	0.3	1.7	3.2	4.7	6.2	3.2
-125	HH-51	Holly	13.0	1.8	3.2	3.7	4.5	5.2	3.7
-128	93HX3	Holly	13.0	2.2	2.8	4.7	6.3	7.7	4.7
-132	93HX4	Holly	12.3	0.5	0.7	2.8	4.0	5.5	2.7
-133	90C 63-04	Holly	11.5	1.7	1.8	3.3	5.0	6.0	3.6
-135	Rhizosen Plus	Holly	12.2	1.3	2.7	3.8	5.5	6.5	4.0
-139	90-1459-0108	Holly	12.2	0.8	2.7	4.0	5.7	6.0	3.8
-140	89C 58-07	Holly	12.7	1.2	2.3	4.5	6.2	7.5	4.3
-154	93HX20	Holly	12.3	0.8	2.3	3.7	5.0	6.2	3.6
-158	HH-91	Holly	12.0	1.7	2.0	4.3	6.5	7.8	4.5
-164	HH-41	Holly	11.2	1.5	2.3	4.0	5.5	6.5	4.0
-167	HH-37	Holly	12.5	0.8	1.2	3.2	4.8	6.3	3.3
-169	HH-79	Holly	13.0	2.0	3.8	5.2	7.0	8.3	5.3

TEST 1893. CODED POWDERY MILDEW TEST,
SALINAS, CA., 1993

(cont.)

Entry No.	Variety	Co.	Beets/ Plot No.	Powdery Mildew Score 8/06	8/10	8/24	8/31	9/16	Mean
PM- 8	HM 5330	Hill-MH	12.8	0.3	2.0	3.0	4.8	5.7	3.2
- 11	HM 3022	Hill-MH	12.8	1.7	2.8	4.3	6.0	7.0	4.4
- 15	HM 3027	Hill-MH	13.2	0.2	2.5	3.3	4.5	5.7	3.2
- 21	HM 3024	Hill-MH	13.3	1.7	3.0	3.7	5.0	5.7	3.8
- 22	HM 3019	Hill-MH	11.3	0.8	2.8	4.2	5.2	6.3	3.9
- 35	HM 3037	Hill-MH	12.7	1.5	3.0	3.8	5.2	6.7	4.0
- 36	HM 3029	Hill-MH	12.5	1.3	2.3	4.5	6.5	7.5	4.4
- 46	HM 3032	Hill-MH	12.8	0.8	1.8	3.3	4.7	5.8	3.3
- 50	HM 3034	Hill-MH	13.2	1.8	3.3	4.0	5.8	7.5	4.5
- 71	Hill 2	Hill-MH	12.5	0.2	0.7	2.7	4.0	5.8	2.7
- 77	HM 6036	Hill-MH	13.2	0.8	1.3	2.8	4.5	5.3	3.0
- 85	HM 3036	Hill-MH	13.7	0.2	0.3	0.8	3.3	2.7	1.5
- 90	HM 3033	Hill-MH	13.8	0.7	1.3	2.3	4.2	6.0	2.9
- 95	HM 3035	Hill-MH	13.7	0.3	0.8	2.0	2.7	3.8	1.9
-103	HM 3031	Hill-MH	13.3	1.3	2.2	3.2	6.2	7.8	4.1
-106	HM 3040	Hill-MH	12.7	1.3	2.5	4.0	5.7	6.8	4.1
-116	HM 6027	Hill-MH	13.7	1.5	2.5	3.7	4.7	6.2	3.7
-130	HM 3026	Hill-MH	12.5	0.7	2.7	3.8	5.8	6.8	4.0
-145	HM 3005	Hill-MH	13.2	1.0	1.5	3.8	5.2	6.7	3.6
-147	HM 3013	Hill-MH	12.2	0.5	2.5	4.2	6.5	7.0	4.1
-148	HM 3030	Hill-MH	13.2	0.2	1.0	2.3	4.7	5.8	2.8
-150	HM 3012	Hill-MH	12.7	2.2	3.5	5.2	7.5	7.8	5.2
-157	HM 3016	Hill-MH	12.2	0.8	2.5	3.3	4.7	6.2	3.5
-162	HM 3038	Hill-MH	12.7	0.3	1.7	2.3	4.7	6.5	3.1
-168	HM 3025	Hill-MH	13.0	1.3	3.0	4.7	6.5	7.5	4.6
PM-176	H90446	Klamath	12.8	1.0	2.3	4.0	4.7	5.8	3.6
-177	H90451	Klamath	12.3	1.2	1.7	3.2	4.5	5.5	3.2
-178	H91258	Klamath	12.8	0.3	2.5	2.0	3.0	4.3	2.4
-179	H92510	Klamath	12.7	0.5	2.0	3.0	4.3	6.8	3.3
-180	H92848	Klamath	12.8	0.8	1.7	2.5	4.3	5.2	2.9
PM- 79	US H11	Check	13.0	2.0	3.3	5.3	7.0	7.3	5.0
- 98	US H11	Check	13.2	2.2	4.2	4.8	6.7	7.0	5.0
-114	US H11	Check	13.0	1.7	3.2	4.5	6.2	6.5	4.4
-124	US H11	Check	13.3	1.7	3.3	5.2	6.8	7.8	5.0

TEST 1893. CODED POWDERY MILDEW TEST,
SALINAS, CA., 1993
(cont.)

Entry No.	Variety	Co.	Beets/ Plot No.	Powdery Mildew Score 8/06	8/10	8/24	8/31	9/16	Mean
Checks included by USDA									
PM-181	US H11	USDA	12.7	1.3	3.3	4.7	6.0	7.7	4.6
-182	US H11	USDA	13.0	2.3	3.8	4.7	6.3	7.2	4.9
-183	US H11	USDA	13.7	1.2	3.8	4.5	6.3	7.3	4.6
-184	US H11	USDA	13.0	0.8	2.8	4.5	5.5	6.5	4.0
-185	WS-PM-9	USDA	12.2	0.2	0.2	1.0	1.7	2.3	1.1
-186	WS-PM-9	USDA	12.8	0.0	0.8	0.7	2.3	2.7	1.3
-187	WS-PM-9	USDA	13.0	0.0	0.0	0.7	2.3	2.3	1.1
-188	WS-PM-9	USDA	13.3	0.2	0.2	0.3	2.0	2.7	1.1
-189	C39	USDA	11.3	0.0	0.2	0.8	1.8	3.3	1.2
-190	C39	USDA	10.7	0.0	0.2	0.5	1.3	2.5	0.9
-191	C39	USDA	9.5	0.0	0.0	0.2	1.2	2.8	0.8
-192	C39	USDA	11.8	0.2	0.3	0.5	1.8	2.5	1.1
Mean			12.6	1.0	2.2	3.4	4.8	6.0	3.5
LSD (.05)			1.5	1.3	1.5	1.3	1.4	1.4	1.0
C.V. (%)			10.6	115.3	61.6	34.7	25.3	20.6	26.5
F value			3.5**	2.0**	2.9**	5.4**	6.0**	6.0**	6.5**

Footnote: Powdery mildew scored on a scale of 0 to 9; where 9 = 90-100% of visible leaf area infected. Mean value (area under disease progress curve) most likely represents varietal reaction and differences among varieties. Scoring was stopped when most susceptible entries and US H11 started having lower values.

TEST 1993. INHERITANCE OF POWDERY MILDEW RESISTANCE, SALINAS, CA., 1993

118 PM inheritance lines, 144 entries x 1 rep (except checks)
10 ft. long, 48 blocks, 3 rows

Planted: March 10, 1993
Not harvested for yield

Variety	Description	Stand Count	Powdery Mildew Score 08/06	08/10	08/24	08/30	09/16	Mean	PM Susc.[1] %
2211-# = C37 x 1211 F_1[C37 x (SB x WB97)]									
2211- 2		6	3	4	4	4	5	4.0	50.0
- 3		9	0	4	4	4	4	3.2	25.0
- 4		7	1	3	3	4	5	3.2	25.0
-13		7	0	3	3	5	5	3.2	83.5
-16		10	5	5	5	6	6	5.4	75.0
-17		5	5	5	5	5	5	5.0	83.5
-19		10	5	6	6	6	7	6.0	83.5
2211-#P = 1211-#, 1213-#, 1215-# x C37									
2211- 1P		13	3	4	4	5	5	4.2	62.5
- 2P		11	5	4	4	5	8	5.2	83.5
- 3P		13	3	4	5	5	4	4.2	62.5
- 4P		7	0	4	4	5	4	3.4	62.5
- 5P		14	0	4	3	3	5	3.0	7.0
- 6P		11	3	4	4	4	5	4.0	62.5
- 7P		7	0	3	4	6	6	3.8	83.5
- 9P		13	4	4	4	5	5	4.4	50.0
-10P		11	0	4	4	3	5	3.2	50.0
-11P		10	4	4	5	5	5	4.6	37.5
-12P		11	4	5	6	7	6	5.6	92.0
-13P		7	1	5	4	5	7	4.4	92.0
-14P		6	1	3	4	4	6	3.6	83.5
-15P		9	5	4	5	5	6	5.0	50.0
-17P		7	1	4	4	5	5	3.8	50.0
-19P		12	4	5	4	6	7	5.2	62.5
-20P		13	0	4	5	5	6	4.0	62.5
-21P		11	5	5	7	7	7	6.2	92.0
-23P		11	4	3	4	6	7	4.8	83.5
-24P		15	5	5	5	6	6	5.4	75.0

TEST 1993. INHERITANCE OF POWDERY MILDEW RESISTANCE, SALINAS, CA., 1993

(cont.)

Variety	Description	Stand Count	Powdery Mildew Score 08/06	08/10	08/24	08/30	09/16	Mean	PM Susc.[1] %
2212-# = C37 x 1212	F_1[C37 x (SB x WB242)]								
2212- 2		7	5	4	4	4	6	4.6	71.0
- 3		8	0	3	4	4	3	2.8	7.0
- 4		9	3	6	6	6	8	5.8	50.0
- 6		9	4	5	5	5	7	5.2	71.0
- 7		11	1	3	3	3	5	3.0	50.0
- 9		10	0	3	4	5	8	4.0	62.5
-10		11	1	1	1	3	1	1.4	7.0
-12		10	1	3	3	3	5	3.0	16.0
-13		11	0	5	5	6	9	5.0	96.0
-15		13	0	1	3	3	1	1.6	16.0
-16		10	3	3	3	4	5	3.6	37.5
-17		12	5	6	9	9	9	7.6	100.0
-18		5	3	3	3	4	3	3.2	71.0
-19		11	0	1	3	3	4	2.2	41.0
-20		12	1	4	5	6	7	4.6	71.0
-21		11	1	4	4	5	6	4.0	71.0
2212-#P = 1212-#, 1214-#, 1216-# x C37									
2212- 1P		13	5	5	4	4	5	4.6	7.0
- 2P		12	5	3	3	3	3	3.4	7.0
- 3P		13	0	3	4	5	5	3.4	25.0
- 4P		12	0	6	7	8	9	6.0	83.5
- 5P		13	1	3	3	4	5	3.2	25.0
- 6P		9	3	4	5	5	6	4.6	62.5
- 7P		11	1	3	4	5	5	3.6	62.5
- 8P		15	0	3	4	4	5	3.2	16.0
- 9P		11	0	3	4	4	7	3.6	71.0
-10P		12	0	1	3	3	4	2.2	7.0
-11P		12	5	5	8	9	9	7.2	100.0
-12P		13	3	3	3	4	4	3.4	7.0
-13P		11	1	3	3	3	9	3.8	53.5

TEST 1993. INHERITANCE OF POWDERY MILDEW RESISTANCE, SALINAS, CA., 1993

(cont.)

Variety	Description	Stand Count	Powdery Mildew Score 08/06	08/10	08/24	08/30	09/16	Mean	PM Susc.[1] %
2212-#P = 1212-#, 1214-#, 1216-# x C37 (cont.)									
-15P		10	4	3	3	4	5	3.8	16.0
-16P		11	4	5	5	7	7	5.6	96.0
-17P		7	0	5	6	8	8	5.4	96.0
-18P		11	4	4	4	4	6	4.4	62.5
-19P		10	0	3	4	4	5	3.2	25.0
-20P		9	0	1	4	3	5	2.6	28.5
-21P		11	0	3	4	5	5	3.4	50.0
-22P		4	0	1	3	4	5	2.6	50.0
-23P		10	3	0	0	0	0	0.6	0.0
2217-# = 5747aa x 1217	F_1[5747aa x (SB x WB97)]								
2217- 1		11	1	4	6	9	9	5.8	96.0
- 2		10	1	1	3	3	4	2.4	25.0
- 3		11	1	4	4	5	5	3.8	50.0
- 4		13	1	4	4	4	8	4.2	62.5
- 5		11	1	4	5	7	7	4.8	96.0
- 6		12	1	3	4	5	7	4.0	83.5
- 7		11	1	5	5	5	6	4.4	62.5
- 8		13	1	3	4	5	6	3.8	50.0
- 9		4	0	3	3	4	6	3.2	50.0
-10		11	0	1	4	5	7	3.4	50.0
-11		13	3	6	6	8	9	6.4	100.0
-12		8	4	5	5	7	9	6.0	100.0
-13		10	5	5	5	8	8	6.2	96.0
-14		12	1	1	4	5	6	3.4	50.0

TEST 1993. INHERITANCE OF POWDERY MILDEW RESISTANCE, SALINAS, CA., 1993

(cont.)

Variety	Description	Stand Count	Powdery Mildew Score 08/06	08/10	08/24	08/30	09/16	Mean	PM Susc.[1] %
2217-#P = 1217, 1219, 1221, 1223 selfed									
2217- 2P		12	0	0	0	0	3	0.6	3.5
- 4P		10	3	4	5	6	8	5.2	62.5
-10P		12	0	3	3	4	5	3.0	37.5
-11P		14	0	0	3	3	5	2.2	34.0
-13P		12	2	3	5	5	6	4.2	37.5
-14P		12	0	0	1	3	4	1.6	25.0
2218-# = 5747aa x 1218	F_1[5747aa x (SB x WB97)]								
2218- 1		12	1	1	3	4	8	3.4	71.0
- 2		5	1	1	3	4	5	2.8	50.0
- 3		12	0	5	7	8	9	5.8	100.0
- 4		11	1	3	4	3	4	3.0	7.0
- 5		10	1	4	4	5	5	3.8	50.0
- 6		8	1	4	6	7	9	5.4	87.5
- 7		13	1	4	4	4	7	4.0	71.0
- 8		6	0	3	3	3	5	2.8	25.0
- 9		9	4	4	3	3	6	4.0	37.5
-10		12	1	4	5	6	7	4.6	71.0
-11		11	1	4	3	3	6	3.4	50.0
-12		13	3	4	5	6	9	5.4	87.5
-13		12	0	3	4	4	6	3.4	16.0
-14		9	0	1	3	3	3	2.0	3.5
-15		12	0	4	4	4	5	3.4	16.0
2218-#P = 1218, 1220, 1222, 1244 selfed									
2818- 1P		13	0	0	1	1	4	1.2	7.0
- 2P		12	0	0	3	3	4	2.0	7.0
-10P		11	0	1	3	3	6	2.6	58.5
-11P		12	0	0	1	0	5	1.4	3.5
-13P		11	0	1	4	4	5	2.8	16.0

TEST 1993. INHERITANCE OF POWDERY MILDEW RESISTANCE, SALINAS, CA., 1993

(cont.)

Variety	Description	Stand Count	Powdery Mildew Score[1] 08/06	08/10	08/24	08/30	09/16	Mean	PM Susc.[2] %
2219-# = 5816aa x 1211, 1212, 1217, 1218									
2219- 1		12	3	4	4	4	5	4.0	37.5
- 2		13	3	4	4	5	6	4.4	37.5
- 3		13	4	5	5	5	6	5.0	83.5
- 4		12	4	5	5	5	8	5.4	71.0
- 5		9	7	8	9	9	9	8.4	100.0
- 6		10	0	6	8	8	9	6.2	92.0
- 7		14	3	5	5	6	9	5.6	96.0
- 8		12	5	3	4	3	6	4.2	62.5
- 9		12	4	4	5	8	9	6.0	100.0
-10		12	2	3	4	5	9	4.6	62.5
Checks*									
U86-37	Inc. C37 (L86443)	95	5	5	6	7	7	6	82.9
87-309CMS	C309CMS x C309 (87083)	43	6	6	7	7	7	7	96.0
P201	PMR 1211, 1216	51	2	3	4	4	5	4	24.5
P202	PMR 1217, 1224	52	3	3	4	4	5	4	33.0
5747	4747aa x A	42	3	5	5	6	7	5	80.3

*Mean of 4 to 8 replications.

A high level of resistance to powdery mildew was identified in Beta maritima WB97 and WB242 by Dr. E.D. Whitney. Without prior selection, BC_2F_1 testcrosses (87% sugarbeet) were made and evaluated for the occurrence of highly resistant plants and to get some information on the inheritance of resistance. Plants within individual testcross families appeared to segregate. From a few of these families, the most resistant plant were selected and will be entered into an inheritance study. Backcrosses will continue to be made to sugarbeet to transfer this resistance.

[1]Powdery mildew scored 8/30 and 9/16 on a plot basis on a scale of 0 to 9 where 9 = highly susceptible.
[2]Rating of % susceptible plants within a plot. A plant was considered resistant if it showed no powdery mildew until near leaf sevescence (ratings of 0 and 1).

TEST RZM 393. 1993 EVALUATION OF AMES PI #'s FOR VIRUS YELLOWS AND RHIZOMANIA
SALINAS, CA., 1993

64 entries x 3 reps, RCB
1-row plots, 10 ft. long

Planted: June 10, 1993
Natural infection to BWYV
Harvested: December 6, 1993

P.I.# Variety	Harv. Count[11]	#1 End Use[1]	#5 Pop. Unif.[2]	#12 Mature Leaf Blade Pigment[3]	#19 Petiole Color[4]	#37 Bolting Tend.[5] 8/11	9/25	#61 BWYV[6] Mean	#62 CLS[7]	#66 PM[8]	#74 Rhizomania[9] DI	%H	RZM Score Annuals[10]
PI 408965	---	8	2	2	4	1	1	6.3	---	---	---	---	7.0
PI 470090	61	5	1	1&2	1	2	2	2.3	5.7	3.7	6.4	3.3	---
PI 470091	53	5	1	1&2	1	2	2	3.0	2.3	3.3	7.0	5.7	---
PI 470092	54	5	1	2	1	2	2	3.0	5.0	5.0	6.7	1.9	---
PI 470093	56	5	1	2	1	2	2	3.7	5.7	5.3	6.7	3.6	---
PI 470094	54	5	1	2	1	2	2	2.7	5.0	3.7	6.6	1.9	---
PI 470095	59	5	2	2	1	2	2	2.3	5.3	4.7	6.7	5.1	---
PI 486358	57	5	1	2	1	2	2	4.7	4.7	3.7	6.9	0.0	---
PI 486359	56	5	1	1&2	1	2	2	3.3	5.0	2.7	6.7	0.0	---
PI 504172	2	8	1	2	4	1	1	3.7	2.0	---	6.0	0.0	3.7
PI 504174	---	8	2	1&2	4	3	1	4.3	---	---	---	---	5.7
PI 504175	---	8	2	1&2	4	3	1	4.3	3.0	---	---	---	5.7
PI 504176	---	8	1	2	4	1	1	4.3	---	---	---	---	5.0
PI 504179	4	8	2	1&2	4	3	3	4.0	3.0	4.0	6.0	0.0	4.3
PI 504182	---	8	1	2	4	1	1	3.7	---	---	---	---	5.0
PI 504183	---	8	2	3	4	3	3	4.3	---	---	---	---	6.3
PI 504184	---	8	1	2	4	1	1	3.0	---	---	---	---	4.3
PI 504185	---	8	1	2	4	1	1	4.3	---	---	---	---	6.3
PI 504186	---	8	1	2	4	1	1	3.0	---	---	---	---	5.6
PI 504187	5	8	1	2	4	3	3	4.3	---	---	5.0	0.0	3.7

TEST RZM 393. 1993 EVALUATION OF AMES PI #'s FOR VIRUS YELLOWS AND RHIZOMANIA
SALINAS, CA., 1993

(cont.)

P.I.# Variety	Harv. Count[11]	#1 End Use[1]	#5 Pop. Unif.[2]	#12 Mature Leaf Blade Pigment[3]	#19 Petiole Color[4]	#37 Bolting Tend.[5] 8/11	9/25	#61 BWYV[6] Mean	#62 CLS[7]	#66 PM[8]	#74 Rhizomania[9] DI	%H	RZM Score Annuals[10]
PI 504189	---	8	1	2	4	1	1	3.7	---	---	---	---	5.0
PI 504190	---	8	1	2	4	1	1	4.3	---	---	---	---	6.3
PI 504191	---	8	1	2	4	3	1	5.0	---	---	---	---	5.7
PI 504193	---	8	1	3	4	3	3	4.3	---	---	---	---	6.3
PI 504197	---	8	1	2	4	1	1	4.3	---	---	---	---	5.7
PI 504198	---	8	2	2	4	1	1	3.6	---	---	---	---	4.3
PI 504200	---	8	1	2	4	3	3	3.0	---	---	---	---	5.6
PI 504204	---	8	1	2	4	1	1	5.0	---	---	---	---	4.3
PI 504208	---	8	2	2	4	3	1	5.0	---	---	---	---	3.7
PI 504210	---	8	1	2	4	3	1	4.3	---	1.0	---	---	3.7
PI 504213	---	8	1	2	4	3	1	4.3	---	---	---	---	5.0
PI 504216	---	8	1	2	4	1	1	5.0	---	4.0	---	---	5.0
PI 504247	---	8	2	2	4	1	1	4.3	---	3.0	---	---	4.3
PI 504254	---	8	1	3	4	3	1	4.3	---	0.0	---	---	3.7
PI 504255	---	8	1	2	4	1	1	3.7	---	0.0	---	---	4.3
PI 518311	43	6	1	3	4	2	2	1.0	3.7	5.3	4.3	32.5	---
PI 518403	39	6	1	2	4	2	2	0.7	1.7	5.0	3.8	56.4	---
PI 540596	20	6	2	2	4	3	3	2.4	2.7	3.7	4.9	5.0	4.8
PI 540598	20	6	2	3	4	3	3	2.9	4.0	4.0	5.0	30.0	4.3
PI 540599	23	6	1	2	4	3	3	3.8	4.0	2.0	4.6	34.8	5.0

TEST RZM 393. 1993 EVALUATION OF AMES PI #'s FOR VIRUS YELLOWS AND RHIZOMANIA
SALINAS, CA., 1993

(cont.)

P.I.# Variety	Harv. Count[11]	#1 End Use[1]	#5 Pop. Unif.[2]	#12 Mature Leaf Blade Pigment[3]	#19 Petiole Color[4]	#37 Bolting Tend.[5] 8/11	9/25	#61 BWYV[6] Mean	#62 CLS[7]	#66 PM[8]	#74 Rhizomania[9] DI	%H	RZM Score Annuals[10]
PI 540600	33	6	1	2	4	3	3	3.0	3.0	2.7	4.2	54.5	3.0
PI 540601	57	6	1	2	4	3	3	2.5	2.7	1.7	4.3	38.6	5.0
PI 540602	57	6	1	2	4	3	3	2.7	3.3	2.3	5.0	15.8	4.3
PI 540603	43	6	1	2	4	3	3	2.9	3.3	3.3	4.3	37.2	5.0
PI 540604	38	6	1	2	4	3	3	2.5	3.3	2.4	4.1	44.7	3.0
PI 540605	64	6	1	2	4	2	3	2.7	4.0	3.0	4.6	26.5	5.0
PI 540606	63	6	1	2	4	2	3	3.9	4.3	4.0	4.8	22.2	5.0
PI 540607	56	6	1	2	4	2	3	3.4	5.3	3.0	4.7	21.4	4.0
PI 540608	32	6	1	2	4	3	3	2.0	3.7	2.6	3.9	56.3	5.0
PI 540609	24	6	1	3	4	3	3	3.5	4.0	---	4.3	41.7	3.0
PI 540610	30	6	1	3	4	3	3	2.0	4.0	---	4.6	26.7	5.0
PI 552532	65	5	1	1	1	2	2	5.7	7.3	4.3	6.2	1.5	---
Checks													
N203H15	73	5	1	1	1	2	2	3.0	4.7	7.3	4.9	21.9	---
N244	77	5	1	1	1	2	2	2.0	6.0	6.0	5.6	9.1	---
P201	66	5	2	1	1	2	2	2.3	3.7	4.0	6.2	6.1	---
P202	63	5	1	1	1	2	2	2.0	5.7	3.0	6.1	4.8	---
R204	60	5	2	2	1	2	2	1.7	4.3	2.7	4.9	16.7	---
R221	54	5	1	2	1	2	2	1.3	3.0	6.3	5.5	9.3	---
R222R4	82	5	1	2	4	2	2	3.3	5.0	6.3	3.8	52.4	---
R223	65	6	1	2	4	2	2	1.3	4.7	6.7	4.4	32.3	---
US H11	75	5	1	1	1	2	2	3.0	5.0	3.3	6.4	4.0	---
R139C7	66	5	2	2	1	2	2	2.0	3.3	3.3	5.0	21.2	---
R276-89	76	5	1	2	1	2	2	0.7	3.7	3.0	5.0	22.4	---
SP 7622-0	74	5	1	1&2	1	2	2	3.0	3.0	5.0	5.9	9.5	---

TEST RZM 393. 1993 EVALUATION OF AMES PI #'s FOR VIRUS YELLOWS AND RHIZOMANIA
SALINAS, CA., 1993
(cont.)

[1] #1 End use based upon field plot appearance where: 1=chard; 2=DDR-like; 3=DDR, chard, spinach; 4=fodder; 5=sugar; 6=wild beet type; 7=mixed, 8=annual.

[2] #5 Population Uniformity: 1=all plants alike; 2=uneven different types; 3=mixed, green, red, yellow, high, low, large leaves, small leaves, etc.

[3] #12 Mature Leaf Blade Pigmentation: 1=light green (chard), 2=green, 3=red & green, 4=red, 5=mutant.

[4] #19 Petiole Color: 1=green, 2=pink, 3=red, 4=candy stripe, 5=yellow, 6=mixed.

[5] #37 Bolting Tendency without cold induction: 1=B-(annual)=100%, 2=bb(biennial)-0%, 3=B:bb(mixed) 1-99%. Readings 8/11 and 9/25/93.

[6] #61 Beet Western Yellows (BWYV): 0=immune; 1=very resistant; 3=resistant; 5=intermediate; 7=susceptible; 9=highly susceptible based upon yellowing of leaves. Readings 9/27 and 11/30/93.

[7] #62 Cercospora was not severe enough to classify on 9/24/93. Remaining nonbolted plants were classified on 11/30/93 on a scale of 1-9 with 9 having symptoms on every leaf.

[8] #66 Powdery Mildew classified on 10/6/93 on a scale of 0 to 9 where 9 = 100% of leaf area mildewed.

[9] #74 Rhizomania: DI-disease index based upon 0=no visual symptoms; 1=very minor root symptoms; 3=normal tap root, slight bearding; 5=wine-glass shaped, bearded, moderate damage; 7=severly damaged, loss of tap root; 9=dead due to rhizomania %Healthy=classes (0+1+2+3)/total. Classified at time of harvest, 12/93.

[10] RZM scored on annual plants only on a plot basis. Notes were taken on Annual plants 9/25/93. Plants were pulled and discarded at that time.

[11] Harvest counts were made only on nonbolting plants when they were scored for DI and % Healthy RZM.

64 entries = 52 PI lines from Ames + 12 USDA checks. Checks are: US H11 = highly susceptible to rhizomania, mod. susceptible to BWYV; R139C7 = C39R = moderately resistant to BWYV and rhizomania; SP 7622-0 = susceptible to both BWYV and rhizomania; R223 = composite of plants from B.maritima PI lines that showed resistance to rhizomania in 1991 test; R222R4 = cycle 4 synthetic of sugarbeet x B.maritima selected for resistance to rhizomania; R276-89 = sugarbeet line that segregates for Rz resistance to rhizomania.

Conclusion: Roots within some lines of B.maritima showed resistance to rhizomania. Two hundred individual plants were selected and will be crossed to sugarbeet to determine the nature and inheritance of this resistance. Many of the B.maritima lines showed very mild symptoms to BWYV. The dark green, thick leaves of B.maritima have a tendency to mask virus yellows symptoms. Crosses to sugarbeet will be made to determine if this apparent resistance is heritable. Plots were found free of nematode infestation but this is thought to be field variability rather than genetic resistance.

CHARACTERIZATION OF THE VARIATION AMONG FUROVIRUSES INFECTING SUGARBEETS

G. C. Wisler, J. E. Duffus, and H.-Y. Liu

BNYVV was first detected in the U.S. in 1983 (Duffus et al., 1984). Several other viruses with similar particle morphology to BNYVV have been isolated from sugarbeet roots from Texas (Liu and Duffus, 1987), Nebraska, Idaho, and Colorado. Some of these isolates have been shown to cross-react with antisera to the BNYVV virion in ELISA tests and in western blot analyses. Thus, the possibility exists for misdiagnosis in sensitive tests which are based on serology of the capsid protein.

BNYVV isolates from Europe have been extensively studied with regard to the genomic organization, function of encoded proteins, and transmission by *Polymyxa graminis*. Many serological and nucleic probes have been developed to different regions of the BNYVV genome. In order to fully characterize and distinguish BNYVV from the other related furoviruses of sugarbeet, similar investigations must be done.

Serological analyses including enzyme-linked immunosorbent assay (ELISA), western blot, and immunodiffusion have been used to evaluate the BNYVV isolates from the U.S., as well as eight other furoviruses of sugarbeet. Serological probes, both polyclonal and monoclonal antisera, have been kindly supplied by several researchers (K. Richards, L. Torrance, and G. Grassi). These antisera have been produced to both structural (i.e., coat protein) and nonstructural (i.e., proteases, polymerases, movement protein) proteins of BNYVV and to two non-BNYVV furoviruses which originated from Texas. In addition, nucleic acid primers specific to the BNYVV genome were used in polymerase chain reaction (PCR) analyses. These techniques were used to evaluate the similarities and differences among the BNYVV isolates and between BNYVV and the other furoviruses of sugar beet. The ability of *P. betae* to transmit some of the non-BNYVV isolates was also evaluated.

The nature of relatedness between five beet necrotic yellow vein virus (BNYVV) isolates, (three from California, one each from Nebraska and Idaho) and eight other rigid, rod-shaped virus isolates of sugarbeet (two from Texas, five from Nebraska, and one from Idaho) was evaluated in this study using western blot analyses, immunodiffusion, and RT-PCR. Antisera to the BNYVV virion showed strong reactions in western blots at ca. 22-kDa for the five BNYVV isolates, and weak reactions at 24-kDa for the eight other rod-shaped virus isolates. Reciprocal tests using antisera to the whole virion of two rod-shaped virus isolates from Texas (referred to as beet soil-borne mosaic virus-1 and -2; BSBMV-1 and -2, Liu and Duffus, 1987) showed strong bands at 24-kDa for all eight rod-shaped isolates and weak bands at 22-kDa for the five BNYVV isolates. Antisera to the C-terminus of the BNYVV capsid protein, seven BNYVV monoclonal antibodies, and the

75-kDa and 14-kDa nonstructural proteins of BNYVV reacted only with the five BNYVV isolates. Antisera to the 25-kDa nonstructural protein reacted to three of five BNYVV isolates. Antisera to the 42-kDa nonstructural protein reacted with all five BNYVV isolates at ca. 42-kDa, and with the eight other isolates at ca. 44-kDa. Results of western blot analyses are summarized in Table 1.

No cross-reactivity between BNYVV isolates and those isolates related to BSBMV-1 and -2 was seen in reciprocal immunodiffusion tests using purified virus preparations (ca. 0.1 mg/ml) and crude sap as the antigen.

The products observed in RT-PCR among four BNYVV isolates (two from California, one each from Idaho and Nebraska) using primers specific for RNA 1, 2, and 3 were identical, whereas the products for RNA 4 varied. BSBMV-1 and -2 and a related isolate from Nebraska (NE10) did not react with any BNYVV primer pair tested. Results from RT-PCR tests are summarized in Table 2.

Preliminary transmission studies indicate BSBMV-2 and NE10 to be transmitted by *Polymyxa betae* Keskin. Results from this study suggest that the isolates related to BSBMV-1 and -2 belong to the furovirus group, but are distinct from BNYVV.

Table 1. Summary of Western Blot Analyses of Sugarbeet Furoviruses

Isolates	Antisera: BNYVV-coat protein	BSBMV-1&2	coat protein: C-terminus	anti-P75	anti-P42	anti-P14	anti-P25	MAbs 41, 47	MAbs 6,7,8, 9,10
BNYVV-GH	+,22k	(+,22k)	+,22k	+,75k	+,42k	+,14k	-	+,22k	+,22k
BNYVV-CA-1	+,22k	(+,22k)	+,22k	+,75k	+,42k	+,14k	+,25k	+,22k	+,22k
BNYVV-CA-12	+,22k	(+,22k)	+,22k	+,75k	+,42k	+,14k	+,25k	+,22k	+,22k
NE-8-1	(+,24k)	+,24k	-	-	+,43k	-	-	-	-
NE-8-3	(+,24k)	+,24k	-	-	+,43k	-	-	-	-
BNYVV-NE-8-4	+,22k	(+,22k)	+,22k	+,75k	+,42k	+,14k	+,25k	+,22k	+,22k
NE-8-5	(+,24k)	+,24k	-	-	+,43k	-	-	-	-
NE-10	(+,24k)	+,24k	-	-	+,43k	-	-	-	-
NE-KW	(+,24k)	(+,22k)						-	-
BNYVV-ID-47	+, 22k	(+,22k)	+,22k	+,75K	+.42k	+,14k	+,25k	+,22k	+,22k
ID-31051	(+,24k)	+,24k	-	-	+,43k	-	-	-	-
BSBMV-1	(+,24k)	+,24k	-	-	+,43k	-	-	-	-
BSBMV-2	(+,24k)	+,24k	-	-	+,43k	-	-	-	-
Healthy *C. quinoa*	-	-	-	-	-	-	-	-	-
Healthy *B.macro.*carpa	-	-	-	-	-	-	-	-	-

Note: Antisera to genetically engineered proteins are courtesy of K. Richards; to monoclonal antibodies (MAbs) (MAbs 41 and 47) couresty of G. Grassi, and MAbs 6,7,8,9, and 10 courtesy of L. Torrance.
k=kilodaltons
- = no detectable reaction
(+,24k) or (+,22k) indicate a heterologous reaction, unlike the strongly positive homologous reaction.

Table 2. RT-PCR Analyses of Several Virus Isolates from Sugarbeet

	PRIMER PAIRS									
	RNA-1		RNA-2				RNA-3	RNA-4		
Isolates	1 & 3	2 & 4	1 & 6	5 & 7	CP	42K	1 & 8	1 & 12	1 & 11	11&13
BNYVV CA-GH	1000[a]	550	300	220	600	1100	250[b]	320 450 600	900	250 400 800
BNYVV CA-1	1000	550	300	220	600	1100	250	320 450 600	1100	250 450
BNYVV NE 8-4	1000	550	300	220	600	1100	250	400 700	1100	250 450 800
BNYVV ID 47	1000	550	300	220	600	1100	250	450 600	1100	250
BSBMV-1	-	-	-	-	-	-	-	-	-	-
BSBMV-2	-	-	-	-	-	-	-	-	-	-
NE 10	-	-	-	-	-	-	-	-	-	-
expected size (bp)	1039	564	195	209	564	1151	218	465	941	249

[a] Values shown in table are estimates based on agarose gel and acrylamide gel electrophoresis.

[b] This product was barely visible on the gel which may correspond to the lack of reactivity of this isolate to the 25-kDa antisera in western blots, corresponding to RNA-3.

- = no products detected

Genetic Analysis of *Polymyxa betae* infected sugar beet roots using the polymerase chain reaction.

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Polymyxa betae, the fungal vector of BNYVV, is an obligate root parasite of sugarbeet. Total DNA was isolated from healthy beet tissue and *Polymyxa*-infected root tissue and amplified using the polymerase chain reaction (PCR)(1,2). DNA was amplified using primers specific for fungal ribosomal DNA (ITS 2 and ITS 4) (3) and with several non-specific RAPD (random amplification of polymorphic DNA) primers (4). DNA polymorphisms within the fungal ITS (internal transcribed spacer) regions of the ribosomal DNA were not observed in different isolates of *P. betae* infecting sugarbeet (Fig.1). A single 750 bp (base pair) amplification product was amplified from non-infected sugarbeet tissue. An additional 480 bp product was present in amplifications from *Polymyxa* -infected sugarbeet roots. The relative intensities of the 750 bp and 480 bp bands were variable in different preparations and may represent differences in the proportion of fungal DNA within the total DNA preparation.

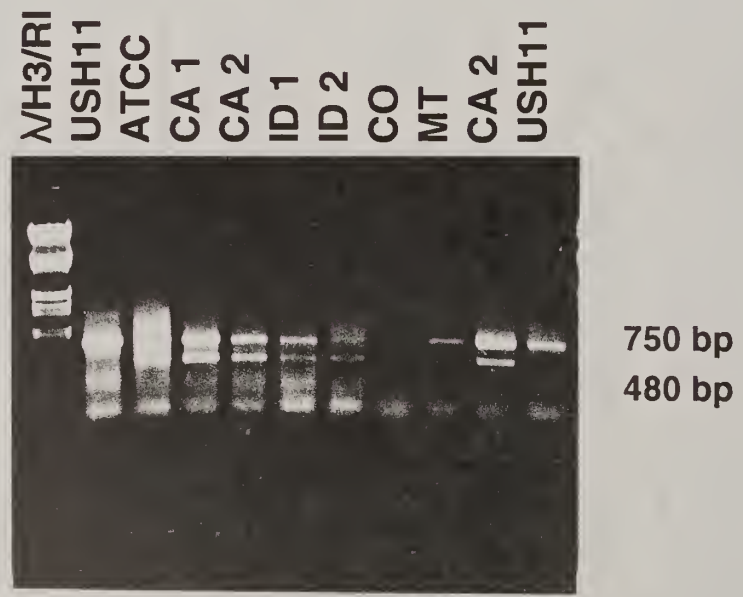

Fig.1. PCR analysis of the ribosomal ITS1 region of non-infected (USH11) and *Polymyxa*-infected *Beta vulgaris* (ATCC (American type culture collection), CA 1, CA 2, ID 1, ID 2, CO, MT, CA 2). Molecular weight standard was λ DNA digested with restriction enzymes *Hind*III and *Eco*RII

DNA from *Polymyxa*-infected *Portulaca* and *Polymyxa*-infected *Amaranthus* was also amplified using the ribosomal ITS primers (Fig.2). A single product (~750 bp) was amplified from DNA isolated from non-infected *Amaranthus* and no product was

amplified from non-infected *Portulaca*. An additional 620 bp or a 500 bp product were observed when DNA from different *Polymyxa*-infected *Amaranthus* were amplified. A slightly smaller product (~480 bp) was periodically amplified from infected-*Portulaca*.

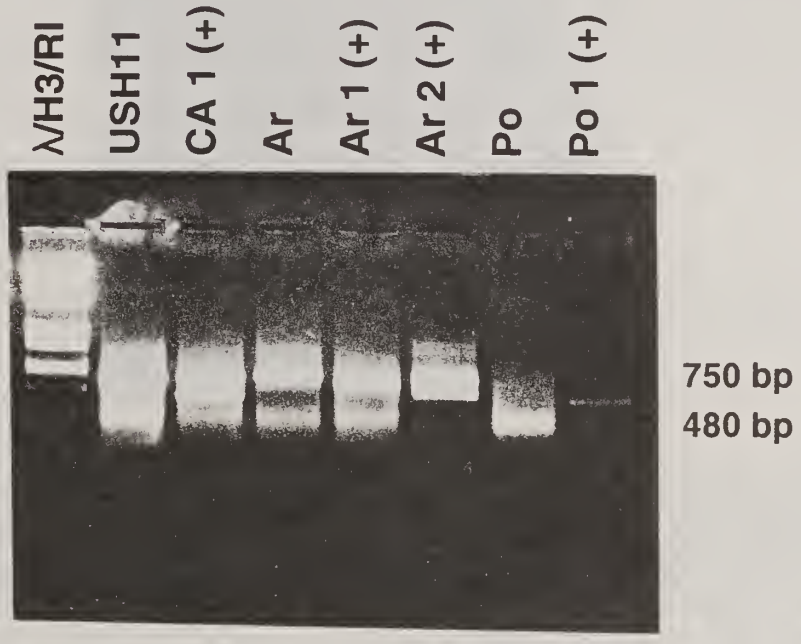

Fig.2. PCR analysis of the ribosomal ITS1 region of *B.vulgaris* (USH11), *Polymyxa*-infected *B.vulgaris* (CA 2), *A.retroflexus* (Ar), *Polymyxa*-infected *A.retroflexus* (Ar 1, Ar 2), *P.oleraceae* (Po), and *Polymyxa*-infected *P.oleraceae* (Po 1). Molecular weight standard was λ DNA digested with restriction enzymes *Hind*III and *Eco*RI.

Total DNA from sugarbeet roots was also amplified using random DNA primers (RAPD analysis). Several products were present in amplifications of DNA from *Polymyxa*-infected root tissue that were absent from amplifications of DNA from non-infected tissue. In addition, there was some variation in RAPD products when DNA from different sugarbeet isolates of *P. betae* were amplified. Putative *P.betae*-specific RAPD products have been excised from agarose gels and cloned into pCR-Script plasmids (Stratagene). These RAPD clones will be used as probes in Southern hybridizations with DNA isolated from *Polymyxa*-infected beet tissue.

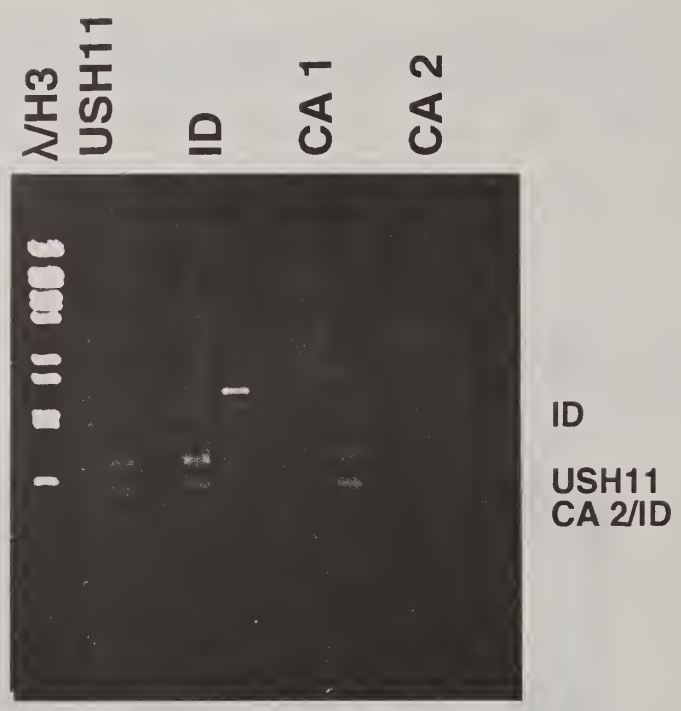

Fig.3. RAPD amplification of Total Root DNA using Operon primer (AB-02). *B.vulgaris* (USH11), *Polymyxa*-infected *B.vulgaris* (ID, CA 1, CA 2). Putative *P.betae*-specific products are indicated. Molecular weight standard was λ DNA digested with restriction enzyme *Hind*III.

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1. Pilgeram, A.L. and J.E. Duffus, 1993. RAPD Analysis of *Polymyxa betae*. Pages 91-93 *in*: Proceedings of the second symposium of the international working group on plant viruses with fungal vectors. Montreal, Canada.

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Project Title: **Evaluation of Photosynthetic Parameters in the Selection of Varieties with Improved Rates of Sugar Production**

Project Number: # 250

Project Leader: Norman Terry, Professor

Other Personnel: Adel M. Zayed — Postdoctoral Researcher
Jodi Azulai — Staff Research Associate

Project Location: 111, Koshland Hall, Dept. Plant Biology,
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Justification for Research:

The overall goal of this research is to identify physiological parameters in young plants which can serve as markers to facilitate the selection of superior-yielding sugar beet genotypes. Specifically we have chosen chlorophyll fluorescence since our results show that the sucrose content of storage roots is linked physiologically to chlorophyll fluorescence. Large numbers of very young plants can be screened very quickly using the highly portable and sophisticated pulse modulated PAM fluorometer. The idea we wish to test is that pulse-modulated fluorescence can be used as an innovative screening method for the rapid identification of plants with superior yield potentials. In previous years, we found three fluorescence parameters, q_E, $(F_v)_s$ and F_v/F_m, which were highly promising as yield predictors, i.e., selection for these parameters in a population of young plants was successful in predicting which plants would later have high sucrose yields or % sucrose. The long-term goals of our research are 1) to develop the fluorescence approach into a simple and easily-workable technique for the rapid selection of high yielding genotypes, and, 2) to apply the technique for the actual development of new better-yielding varieties.

Summary of Literature Review and Progress-to-Date:

1. Literature Review

Chlorophyll fluorescence emitted by green plants is a measure of the photosynthetic activity of the leaf and originates mainly from chlorophyll a in photosystem II (PS II). Hence, fluorescence yield reflects the properties of excitation and energy conversion at PS II. However, due to the functional connection of PS II to the other components of the photosynthetic apparatus, fluorescence yield is considered to be an indicator of the whole complex process (Schreiber and Bilger, 1987). Recent improvements in fluorescence techniques, particularly the development of the pulse modulation chlorophyll fluorometer, have served to increase the value of fluorescence as a nonintrusive method of monitoring photosynthetic events and judging the

physiological state of the plant (Krause and Weis, 1991). Recent studies have proven that chlorophyll fluorescence provides a rapid non-destructive method for studying heat and drought stress tolerance in plants (Ogren, 1990; Prange et al., 1990; Jefferies, 1992; Smillie, 1992).

Apart from the research conducted in our own laboratory, there are very few if any studies which have attempted to correlate fluorescence parameters with root sucrose yield. It is thought that sucrose storage and partitioning is physiologically linked to photosynthetic rate (Wardlaw, 1990) and that changes in the latter are reflected by changes in fluorescence (see also Krause and Weis, 1991). Interestingly, Krause and Weis (1991) indicated that the F_v/F_m ratio has become an important and easily measurable parameter of the physiological state of the photosynthetic apparatus in intact plant leaves. Furthermore, Schreiber and Bilger (1987) stated that high levels of $(F_v)_s$ are associated with low q_E, and that this reflects efficient energy utilization by the Calvin cycle. In our research we found that these three parameters (i.e., F_v/F_m, $(F_v)_s$, q_E) are the best correlated with sugarbeet sucrose yield and that high $(F_v)_s$ is always associated with low q_E and high root sucrose content.

2. 1993 Greenhouse Experiment

During the past year, we sought to optimize the experimental procedure for using pulse-modulated fluorescence to develop new high-yielding genotypes. Our objectives were to: 1) increase the size of the selection sample as well as that of the total population screened, 2) to provide growing conditions which minimized competition between plants for light and nutrients, and 3) to increase the length of time between fluorescence measurement and harvesting (particularly for root sugar content). We carried out the experiment inside a computer-controlled greenhouse which maintains temperatures and irradiance within certain defined limits. This facility enabled us to grow the plants in a single controlled environment, to illuminate the plants at high light intensities (up to 2000 umol m^{-2} s^{-1}) and with one plant per 20-L container so that mineral nutrient supply was not limiting.

Two weeks after transplanting, chlorophyll fluorescence of the attached leaves was measured using the pulse modulation chlorophyll fluorometer Model PAM 101 (H. Walz, Effeltritch, FRG). At the end of the fluorescence measurement period (5 days), the 30 plants exhibiting the highest values and the 30 plants with the lowest values of each of the two fluorescence parameters, $F(v)_s$ and F_v/F_m, were selected and transferred into 20-L containers. The plants grew significantly faster than in growth chambers and by the end of 6 weeks had reached sufficient size for harvesting.

The 1993 experiment was successful in that we were able to increase the size of the selection sample at screening (increased from 24-27 plants in 1992 to 100 plants in 1993) and

the size of the total population screened (from 195 plants in 1992 to 585 plants in 1993). Furthermore, the new greenhouse enabled us to illuminate the plants at much higher light intensities than in the growth chambers and to eliminate competition for nutrients (one plant per pot, nutrients replaced weekly). The plants were re-randomized in their position in the greenhouse weekly also. We did not need to increase the time from selection to harvest because the plants grew so fast under these conditions. However, the use of the greenhouse facility also brought with it some new difficulties which we did not encounter in the growth chambers. For example, when the young plants (5 weeks from sowing) were transferred to the greenhouse from the growth chamber, they suffered heat shock and wilted severely. Most plants recovered but some were replaced. Then 2 weeks after transplanting, Berkeley experienced an unusual heat wave for about 1 week. This resulted in damage to the faster-growing plants which wilted more readily than the slower-growing, smaller plants. We also experienced fungal infection of the roots which changed the rate of growth of some plants and increased variability.

What did the results from the 1993 experiment show? We selected at the seedling stage for the two fluorescence parameters, $F(_v)_s$ and F_v/F_m, i.e., we selected plants which exhibited the 30 highest values and the 30 lowest values for each parameter (giving a total of 100 plants). We grew the plants for 6 weeks and measured the storage root sugar yield and % storage root sucrose as well as fresh and dry weights of plant parts. Ten plants which exhibited serious root damage and other defects were eliminated from the analysis. The remaining 90 plants were tested for statistical correlations between root sugar yield, or sucrose %, with $F(_v)_s$ or F_v/F_m (Table 1). The results show that young

Table 1. Greenhouse Experiment 1993: Correlation coefficients of fluorescence parameters with important growth and yield attributes of the selected plants

	St.Rt.F.Wt.	St.Rt.D.Wt.	Rt.D.Wt.%	Sugar %	Total sugar
F_o	-0.390***	-0.414***	0.108	0.097	-0.382***
$F(_v)_m$	-0.326**	-0.296**	0.167	0.188	-0.295**
F_v	-0.346***	-0.299**	0.259*	0.357***	-0.277**
$q_Q.F(_v)_s$	-0.242*	-0.182	0.213*	0.240*	-0.201
$q_E.F(_v)_m$	0.239*	0.162	-0.274**	-0.340***	0.174
F_m	-0.365***	-0.348***	0.163	0.176	-0.339***
$q.F(_v)_m$	-0.070	-0.079	-0.036	-0.086	-0.095
q_Q	0.196	0.198	-0.114	-0.255*	0.137
q_E	0.260*	0.184	-0.275**	-0.337**	0.197
$F(_v)_s$	-0.306**	-0.245*	0.250*	0.309**	-0.249*
F_v/F_m	-0.294**	-0.245*	0.255*	0.388***	-0.215*

*,**,*** = significant at P=0.05, P=0.01, P=0.001, respectively.

plants selected for high $F(_v)_s$ or high F_v/F_m subsequently exhibited storage roots which had high % sucrose but low total

root sugar yield (Table 1, Figs. 1,2). This finding confirmed last year's results with respect to sucrose % but differed for root sugar yield which was correlated positively with high $F(_v)_s$ or high F_v/F_m in previous years' experiments (see Reports for 1993, 1992). In this year's experiment, plants selected for high $F(_v)_s$ or high F_v/F_m had smaller root sizes as indicated by the smaller storage root dry and fresh weight (Table 1).

Other significant correlations were obtained (Table 1). For example, high $F(_v)_s$ or high F_v/F_m was found to be correlated with high storage root percentage dry matter. When fluorescence parameters other than $F(_v)_s$ or F_v/F_m were considered, we found that storage root sugar content correlated positively with high values of F_v and $q_Q.F(_v)_s$ and correlated with low values of $q_E.F(_v)_m$, q_Q and q_E. Total storage root sugar yield correlated negatively with F_o, $F(_v)_m$, F_v and F_m.

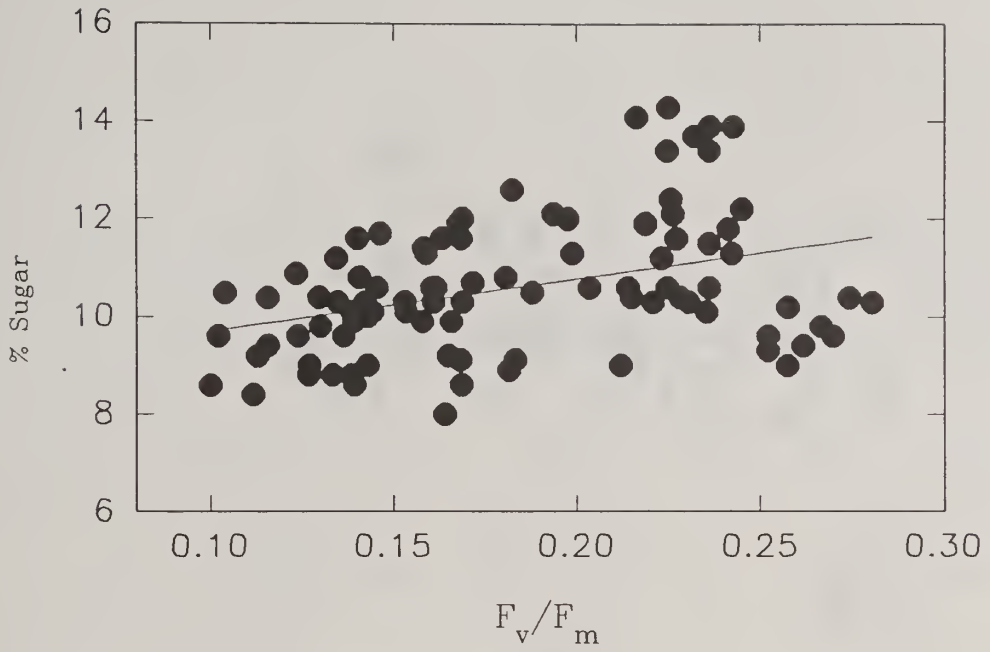
3. Field Trial Statistical Analysis

Dr. Harm Schipper (Van der Have) carried out a statistical analysis to see how well fluorescence parameters obtained by the Terry Lab at University of California, Berkeley, correlated with sugar yields in a field trial carried out by Van der Have in The Netherlands. Plants of 39 different seedlots were compared. The objective of Dr. Schipper's analysis was to determine whether high sugar-yielding genotypes exhibited fluorescence characteristics which would identify them as high-yielding genotypes. Dr. Schipper's analysis was exciting because it showed that sugar yield was correlated significantly (in some instances up to P = 0.001) with several different fluorescence parameters. The data show that there was a highly significant positive correlation between white sugar yield (WSY) and F_o, F_m, F_v, $F(_v)_s$, and $F(_v)_m$ (Table 2). Similarly, sugar concentration (SC)

Table 2. Field Study Analysis: Correlation coefficients among field sugar yield data of 39 seedlots and laboratory-measured fluorescence parameters. Fluorescence was measured for 15 representative plants of each seedlot and the average was correlated with the average sugar yields obtained from the field trial

	CRY	WSY	SC
F_o	0.286	0.462**	0.199
F_m	0.256	0.465**	0.255
F_v	0.463**	0.461**	-0.150
F_v/F_m	0.409**	0.264	-0.362*
$F(_v)_s$	0.192	0.386*	0.268
$F(_v)_m$	0.221	0.426**	0.258
q_E	-0.019	-0.063	-0.097
q_Q	-0.444**	-0.293	0.396*
$q_E.F(_v)_m$	0.046	0.054	-0.031
$q_Q.F(_v)_s$	-0.088	0.158	0.442**
$q.F(_v)_m$	-0.060	0.207	0.448**

*, ** = significant at P=0.05 and P=0.01, respectively.



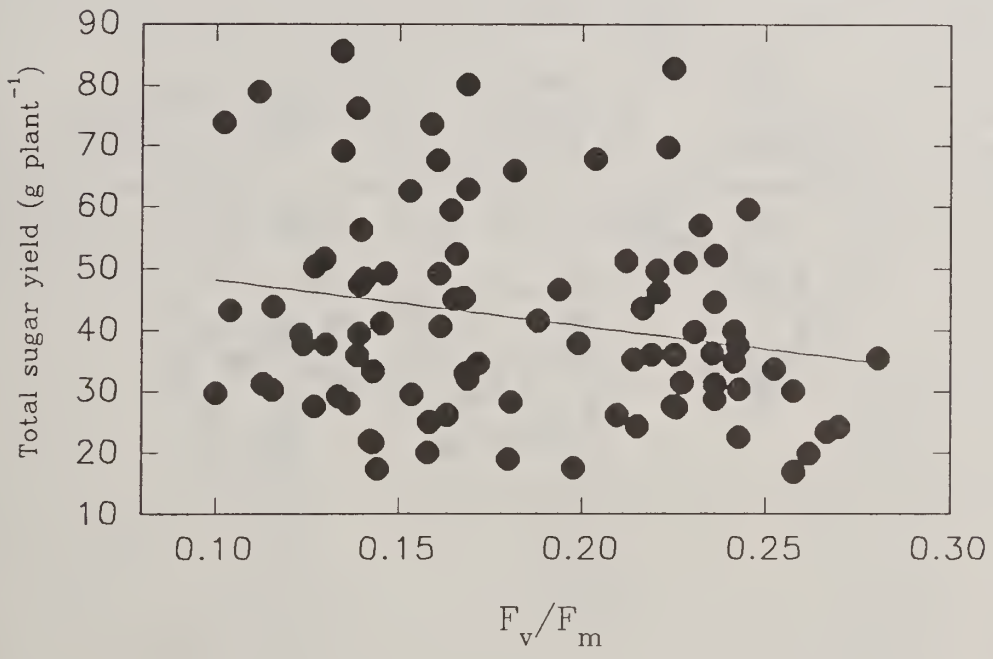
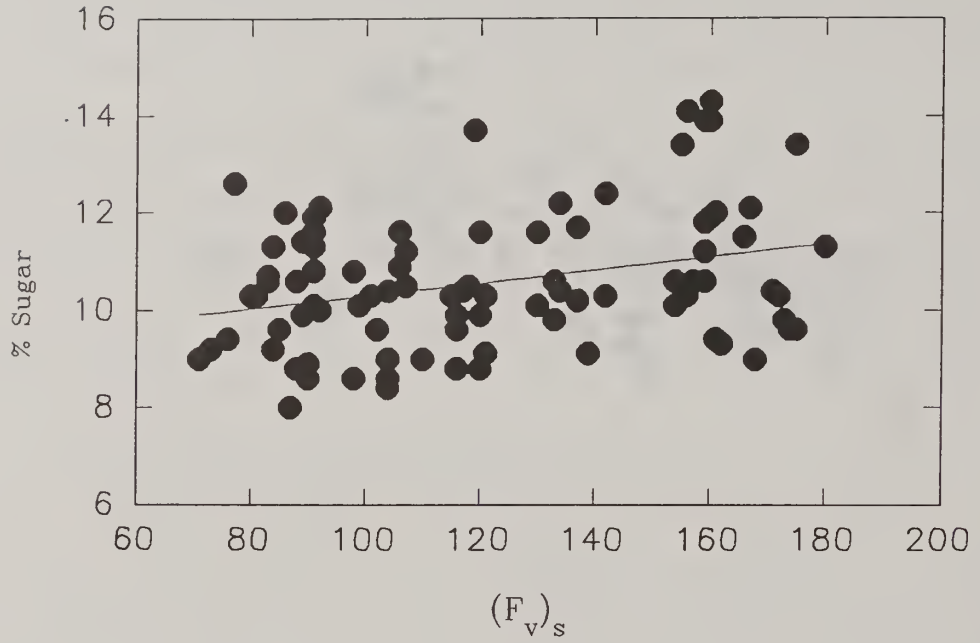


Fig. 1: Relationship between F_v/F_m, measured at selection time, and root sugar concentration (above) and total sugar content (below) in storage root at time of harvest, six weeks later.



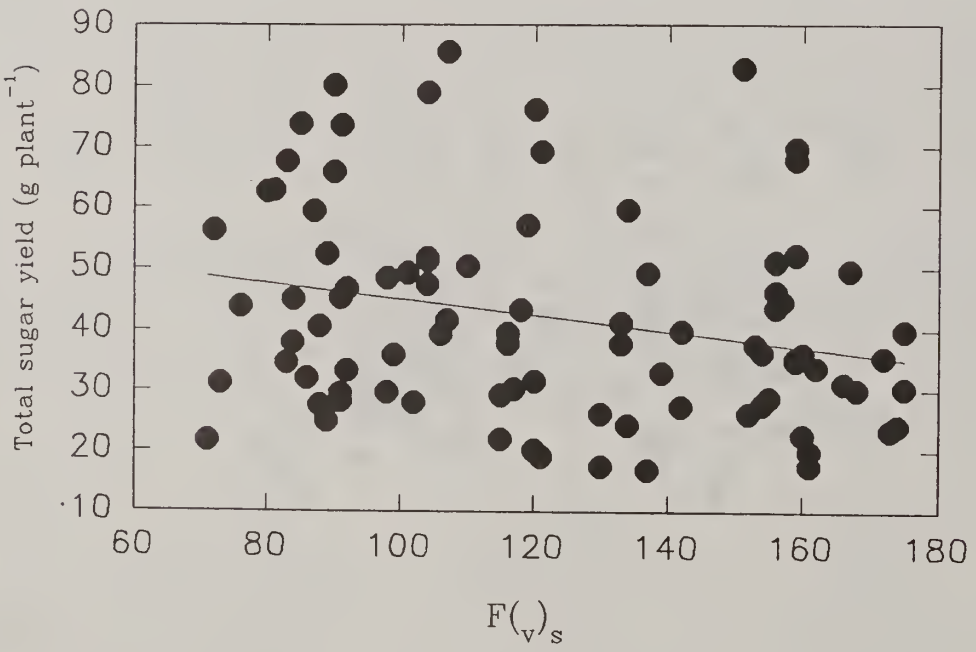


Fig. 2: Relationship between $F(_v)_s$, measured at selection time, and root sugar concentration (above) and total sugar content (below) in storage root at time of harvest, six weeks later.

was significantly correlated with F_v/F_m (negative correlation), q_Q, $q_Q.F_{(v)s}$ and $q.F_{(v)m}$ (Table 2). When Group 1 seedlots (1a-25a) only were considered, significant correlations were found between WSY and F_o and F_m, and between SC and F_v/F_m and q_Q (Table 3). With regard to Group 2 seedlots (1b-14b), WSY was highly correlated with F_v, F_v/F_m, $F_{(v)s}$ and q_E, whereas SC was significantly correlated with $q.F_{(v)m}$ (Table 4).

Table 3. Field Study Analysis: Correlation coefficients among field sugar yield data of Group 1 seedlots (1a-25a) and laboratory-measured fluorescence parameters. For each seedlot fluorescence was measured for 15 representative plants and the average was correlated with the average sugar yield obtained from a field trial

	CRY	WSY	SC
F_o	0.413*	0.472*	0.009
F_m	0.411*	0.459*	0.016
F_v	0.521**	0.315	-0.438*
F_v/F_m	0.345	0.091	-0.495*
$F_{(v)s}$	0.148	0.216	0.169
$F_{(v)m}$	0.356	0.392	0.018
q_E	0.199	0.145	-0.217
q_Q	-0.465*	-0.216	0.554**
$q_E.F_{(v)m}$	0.257	0.213	-0.201

*, ** = significant at P=0.05 and P=0.01, respectively.

Table 4. Field Study Analysis: Correlation coefficients among field sugar yield data of Group 2 seedlots (1b-14b) and laboratory-measured fluorescence parameters. For each seedlot fluorescence was measured for 15 representative plants and the average was correlated with the average sugar yield obtained from a field trial

	CRY	WSY	SC
F_o	0.065	0.427	0.533*
F_m	0.099	0.462	0.516
F_v	0.409	0.645*	0.202
F_v/F_m	0.517	0.565*	-0.126
$F_{(v)s}$	0.270	0.577*	0.359
$F_{(v)m}$	0.107	0.458	0.494
q_E	-0.684**	-0.713**	0.236
q_Q	-0.409	-0.470	0.060
$q_E.F_{(v)m}$	-0.675**	-0.523	0.509
$q_Q.F_{(v)s}$	0.078	0.362	0.395
$q.F_{(v)m}$	-0.189	0.157	0.602*

* = significant at P=0.05 and P=0.01, respectively.

Dr. Schipper also developed a number of indices by the addition of the values of several fluorescence parameters as follows:

$$A1 = F_o + F_v$$
$$A2 = F_o + F_v + F(_v)_s$$
$$A3 = F_o + F_v + F(_v)_s + F_m + F(_v)_m$$
$$B1 = q_Q.F(_v)_s + q.F(_v)_m$$
$$B2 = (q_Q.F(_v)_s + q.F(_v)_m) * q_Q$$

These indices were then tested for their correlation with sugar yield from the results of the field trials. When all the 39 seedlots were considered, highly significant correlations were found between WYS and A1, A2 and A3, and between SC and B1 and B2 (Table 5). Similar correlations were also obtained when group 1 and group 2 seedlots were considered separately (Table 5). Figure 3 illustrates how well WSY correlated with the fluorescence index A1.

Table 5. Field Study Analysis: Correlation coefficients among field sugar yield data and fluorescence indices derived from laboratory-measured fluorescence parameters (see text above for the meaning of these indices)

	A1	A2	A3	B1	B2
			All 39 seedlots		
CRY	0.459**	0.342*	0.293	-0.079	-0.259
WSY	0.548***	0.501**	0.484**	0.193	-0.008
SC	0.001	0.159	0.221	0.473**	0.497**
			Group 1 seedlots		
CRY	0.582**	0.421*	0.422*	-0.082	-0.269
WSY	0.481*	0.406*	0.442*	0.127	-0.029
SC	-0.281	-0.055	-0.013	0.427*	0.512**
			Group 2 seedlots		
CRY	0.316	0.295	0.188	-0.056	-0.231
WSY	0.630*	0.611*	0.533*	0.265	-0.0002
SC	0.360	0.366	0.452	0.508	0.435

*,**,*** = significant at P=0.05, P=0.01, P=0.001, respectively.

4. Conclusions

1) Based on Dr. Schipper's analysis and from our results of this and previous years, there is little doubt that high-yielding sugar beet genotypes can be identified by their fluorescence characteristics.

2) The 1993 greenhouse experiment, which was designed to show that selection for high values of $F(_v)_s$ and F_v/F_m can predict those plants with high root sugar yields, was successful

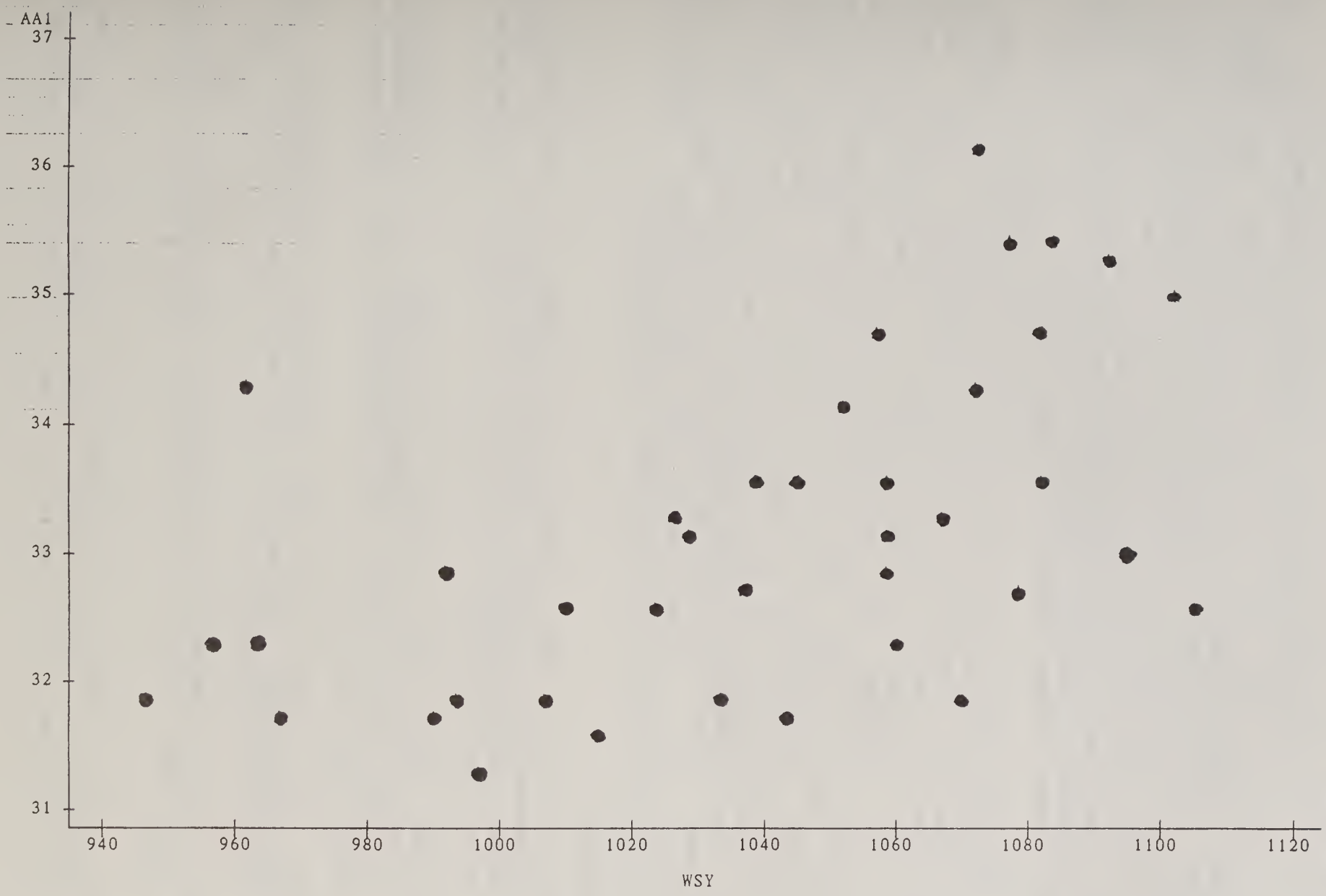


Fig. 3: Relationship between fluorescence index A1 ($A1=F_o+F_v$), measured in our laboratory for young plants of 39 seedlots, and white sugar yield obtained from plants (of the same seedlots) grown in the field in The Netherlands.

in predicting plants with high root sugar concentration (but not sugar yields).

3) The 1993 greenhouse experiment permitted us to increase the sample size at the time of selection and the total size of population screened, and to increase illumination and mineral nutrient supply. However, we also encountered unanticipated setbacks in that plants wilted after transfer from the growth chamber to the greenhouse, suffered damage following an unusual heat wave, and some plants developed fungal infections of their roots. The faster-growing plants were more prone to damage than their slow-growing counterparts and we believe that this, along with increased variability, reduced our chances of obtaining good correlations of sugar yield with fluorescence.

This year we will continue to use the greenhouse to conduct the experiment but we will avoid the difficulties we encountered last year by conducting the whole experiment, from seed germination to harvest, in pots filled with vermiculite and peat moss. By this means we should eliminate transplanting shock, and, root cracking and root fungal infection (in the 1993 experiment, the storage roots cracked when they expanded into the lids of the nutrient solution container; this led to fungal infection). Furthermore, we will attempt to simulate field conditions more precisely by withholding nitrogen from the plants for 2 weeks prior to harvest so that sucrose levels build up in roots. The fluorescence measurements will be carried out in the greenhouse. This will require the use of special adapters to dark-adapt the intact leaves in situ before measuring fluorescence emission under daylight illumination.

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SUGARBEET RESEARCH

1993 Report

Section B

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Abstracts of Papers Published or Approved for Publication

Wozniak, C. A. and L. D. Owens. 1994. Native β-glucuronidase activity in sugarbeet (*Beta vulgaris* L.). Physiol. Plant. 89: (In press).

β-Glucuronidase activity, initially thought absent from plants, has been found in a number of plant families. During an analysis of Agrobacterium-mediated transformation of sugarbeet (Beta vulgaris L.), significant glucuronidase activity was observed in control (non-transformed) tissues when the fluorogenic substrates 4-methylumbelliferyl-β-D-glucuronic acid, resorufin glucuronic acid and 3-carboxyumbelliferyl-β-D-glucuronic acid were used to quantify β-glucuronidase activity under standard protocol conditions. Similarly, the colorigenic substrate p-nitrophenyl-β-D-glucuronide was hydrolyzed by this sugarbeet-derived glucuronidase. Biochemical and immunological data are presented to indicate significant differences between sugarbeet-derived glucuronidase and that of microbial origin (i.e., encoded by *gusA*; E.C. 3.2.1.31). These differences provide means of distinguishing between the two activities in extracts that contain a mixture of both. Use of X-gluc, the substrate utilized in histochemical localizations of glucuronidase activity, gave no reaction product (i.e., indigo precipitate) at pH 7.0. However, at pH 3.0, 4.0 and 5.0 formation of the indigo precipitate was evident within 1 h at 37 °C in sugarbeet callus and by 4 h in leaves and petioles. The specific activity of sugarbeet glucuronidase was observed to be strongly pH dependent, with an optimum near pH 4.0. The use of various β-glucuronidase assay techniques as applied to transformation of sugarbeet is discussed.

Owens, L. D., R. O. Nordeen, J. B. Philbrick and J. C. Ingersoll. 1993. Design and testing of novel genes for plants to defend against bacterial pathogens. Abstr. of Papers, 206th Amer. Chem. Soc. Nat'l Mtg. AGRO 141.

New sources of resistance to microbial pathogens are needed to maintain productivity of agricultural crops. Modern techniques in molecular biology now enable taking a gene from any source, reconstructing it with appropriate regulatory sequences, inserting it into the target plant and having it expressed and inherited as part of the plant genome. This talk will describe investigations to test the feasibility of engineering the cecropin gene from the insect *Hyalophora cecropia* to augment the plant's natural defenses against

pathogenic bacteria. Included will be (1) data on the relative toxicity of cecropin to pathogenic bacteria and to cells of their respective host plants, (2) design and construction of the gene, (3) evidence for expression and heritability of the gene in a model test plant and (4) new physical techniques for inserting genes into plant tissues for rapidly determining how efficiently they will be expressed.

Wozniak, C. A., and L. D. Owens. 1993 Use of β-Glucuronidase (GUS) as a marker for transformation in sugarbeet. J. Sugar Beet Res. (In press).

Accurate quantitation of an introduced genetic or biochemical marker into sugarbeet (*Beta vulgaris* L.) is based on the absence of native activities in the plant that could confound analysis of marker expression. During the course of experiments designed to optimize DNA transfer from *Agrobacterium tumefaciens* to sugarbeet leaf disc cells, an endogenous enzyme activity was discovered which utilizes all the common substrates recognized by the marker enzyme, β-glucuronidase (GUS) from *E. coli*. This native sugarbeet enzyme (SB-GUS) was characterized immunologically and biochemically. GUS and SB-GUS were found to be distinct with regard to pH optima, thermal inactivation, reaction to denaturants and protein modifying reagents, inhibition by metals and saccharo-lactone, and molecular mass. The two activities are not immunologically related, as judged by Western blot and immunoprecipitation analyses. A protocol was developed to accurately quantitate introduced GUS in the presence of SB-GUS, by utilizing selective inhibition of GUS at pH 7.0 by saccharic acid 1,4-lactone. Under these conditions GUS activity is completely eliminated, while SB-GUS activity was unaffected.

Papers Published Since Abstracted in Previous Report

Hassan, M., S. L. Sinden, R. S. Kobayashi, R. O. Nordeen and L. D. Owens. 1992. Transformation of potato (*Solanum tuberosum*) with a gene for an anti-bacterial protein, cecropin. *Acta Hort.* 336:127-131.

Hatfield, D., C. I. Soon, S. Mischke and L. D. Owens. 1992. Selenocysteyl-tRNAs recognize UGA in *beta vulgaris*, a higher plant, and in *Gliocadium virens*, a filamentous fungus. *Biochem. Biophys. Res. Comm.* 184:254-259.

ENGINEERED RESISTANCE TO BACTERIAL PATHOGENS
BSDF Project 800

J. C. Ingersoll and L. D. Owens

Expression of cecropin gene in transgenic tobacco plants - Cecropins are a family of small polypeptides (~40 amino acids in length) that possess potent antibacterial activity against many bacteria, including a number of plant pathogens. A synthetic version of cecropin B, consisting of the coding region of cecropin fused to the secretory sequence from barley α-amylase and placed under control of two different promoters, was introduced into the model test plant tobacco. The promoters used were the enhanced 35S (En35S) promoter from cauliflower mosaic virus and the proteinase inhibitor II (PI-II) promoter from potato.

Preliminary challenge experiments using *Pseudomonas solanacearum* infection of either wounded roots or punctured stems indicated delayed symptom development with the PI-II but not the En35S promoter. Because these experiments occurred over a period of many months, and because many R_0 plants challenged with the En35S construct were lost, a new set of transgenic *Nicotiana tabacum* cv. Bottom Special were produced and vegetatively cloned. One set of cloned lines is being challenged by infiltration of different numbers of *Pseudomonas syringeae* pv. *tabaci* into leaves. The leaves are scored for chlorsis/necrosis symptom development, and leaf discs are punched from replicate infection loci for bacterial counts. Preliminary results with PI-II-cecropin transgenic plants indicate protection at normal levels of infection.

Promoter analysis in sugarbeet cells - Engineered defense genes need to be efficiently expressed in the target plant. In order to study the efficiency of inducible promoters and accompanying 5'-untranslated leader sequences in sugarbeet, various combinations of these elements were fused to the *gusA* gene coding region and used to coat gold microbeads. Previously, these DNA-coated beads were shot into detached sugarbeet leaves to ascertain transient GUS expression. The leaf system, however, gave low numbers of GUS^+ (blue) foci and was highly variable.

To develop a more consistent promoter-analysis system, sugarbeet suspension cell cultures were established from leaf-disc callus. Basically the system consists of layering a fine suspension of cells on a membrane, bombarding the cells with DNA-coated beads, culturing for 24 h to allow expression of the promoter-*gusA* construct and assaying for GUS

expression. The histochemical substrate X-gluc was used in optimization studies. The number of blue foci obtained is an indication of expression efficiency. Highest efficiency was obtained when cells were: layered at a rate of 12 mg FW/cm^2 of membrane (cellulose nitrate or nylon) using a filtration apparatus; precultured for 4 h on medium supplemented with an osmoticum (0.25 OsM consisting of equal amounts of mannitol and sorbitol); bombarded with particles propelled by 1350 psi He at a distance of 10 cm; and postcultured 24 h on the same high-osmotic medium. The membrane and cells were then transferred to filter paper wetted with X-gluc solution and 30 mM ascorbate (to prevent browning) and incubated overnight at 37 °C. These optimized conditions are being used to analyze promoter-*gusA* constructs prepared with promoters derived from the wound-inducible genes osmotin, PR-S and PI-II and the constitutive En35S promoter.

GENE TRANSFER AND CLONING RELATED TO SUGAR PARTITIONING

G. W. Snyder and L. D. Owens

Gene transfer to sugarbeet - Transgenic sugarbeet plants were obtained by coculture of leaf discs with an *Agrobacterium* vector strain. The method used was that described in a French patent held by Le Groupe Limagrain (contact made through Tom Schwartz). Proof of transformation was indicated by growth on kanamycin, strong GUS activity of excised leaf pieces and PCR analysis of DNA. Several defense-gene constructs are currently being introduced.

Cloning of sucrose phosphate synthase gene - A key gene known to exert a major influence in sugar production and export from tomato leaf is the sucrose phosphate synthase (SPS) gene. When a heterologous SPS gene is introduced, the resulting SPS enzyme is less controlled by feedback inhibition mechanisms, and more sucrose is exported from the leaves. We have cloned, in segments, about 3/4 of the SPS gene from maize by PCR techniques. The plan is to place the entire coding region of this gene under control of a taproot-expressed promoter and introduce the construct into sugarbeet.

SUGARBEET RESEARCH

1993 REPORT

Section C

Crops Research Laboratory, Agricultural Research Service
U.S. Department of Agriculture, Fort Collins, Colorado

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Dr. Susan S. Martin, Plant Physiologist
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Cooperation:

Colorado Agricultural Experiment Station

This research was supported in part by funds provided through the
Beet Sugar Development Foundation
(Projects 402, 903, and 904)

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PUBLICATIONS

Abstract of Paper Approved for Publication

Ruppel, E. G. and R. J. Hecker. 1994. Rhizoctonia root rot on sugarbeet cultivars having varied degrees of resistance. J. Sugar Beet Res. 31:(in press)

To address a concern that yield losses may be greater in resistant than in susceptible sugarbeet cultivars, five cultivars, including a susceptible and two moderately resistant commercial varieties, a resistant three-way experimental hybrid, and a highly resistant breeding line, were tested in the field in 1989, 1990, and 1991 for their reaction to inoculation with *Rhizoctonia solani* (AG-2-2). Generally, rankings of the cultivars for percent decreases (inoculated versus noninoculated) in root and recoverable sucrose yield and percent sucrose and percent purity tended to be proportional to disease severity indices. With the exception of percent purity in 1990, positive significant or highly significant coefficients of linear correlation between disease index differences (inoculated versus noninoculated) and percent decreases in yield and purity parameters each year indicated that there were no hidden losses to Rhizoctonia root rot in resistant germplasms.

RHIZOCTONIA ROOT ROT RESEARCH AND DEVELOPMENT OF GENETIC RESISTANCE IN SUGARBEET (BSDF Project 402)

1993 Field Research on Rhizoctonia Root Rot of Sugarbeet.--E. G. Ruppel and L. W. Panella.

We have been pleased to lead this cooperative research project of ARS, the BSDF, and the Colorado Agricultural Experiment Station. Our project primarily involved field studies conducted on the Colorado State University South Campus in an area reserved for Rhizoctonia root rot research.

The 1993 field experiments were planted in an area that had been in barley for 3 years and was the site of our inoculated Rhizoctonia nursery in 1989. No Rhizoctonia root rot occurred from residual fungus before inoculation of sugarbeet in 1993. Our 4-year rotation with barley apparently is sufficient for the degradation of *Rhizoctonia*-infected residues in our soils of low organic content.

Rhizoctonia evaluation experiments were planted in one-row plots 56 cm (22 in) apart and 4.3 m (14 ft) long. Experiments were planted in mid-May and thinned to a 20- to 25-cm (8- to 10-in) in-row spacing the third week of June. Dry, ground, barley-grain inoculum of *Rhizoctonia solani* (isolate R-9) was banded over the rows on July 19 at a rate of 8.4 g/4.3-m row with a tractor-mounted four-row granule applicator. Inoculum was banded in a split application, with opposite directions of travel for each application. Immediately after inoculation, we performed a cultivation designed to throw soil into sugarbeet crowns, a practice that we previously identified as being conducive to the development of root and crown rot. Our standard sprinkler irrigation regime was used to moisten and activate the inoculum. Succeeding irrigations were done by furrow. Before field inoculation, we tested inoculum for virulence on 2-mo-old sugarbeets in the greenhouse; our 1993 inoculum was highly virulent, rotting all inoculated plants.

Roots in all experiments were lifted either the last week in September or the first week in October and individually rated for rot on a disease index (DI) scale of 0 to 7, with 0 = no evidence of rot and 7 = plant dead. Percent healthy roots were those with DIs of 0 and 1, roots with no active infection. Roots with DIs 0 through 3 also were analyzed as a class; these roots were sufficiently sound and large to be recovered in a commercial harvest.

Due to the cool, wet summer, our 1993 epidemic of root rot was rather mild, although more intense than our 1992 epidemic. In the critical months of July through September, night low temperatures never exceeded 51°F, and day temperatures also were unseasonably low. With one exception (week four in August), we experienced a departure of -1 to -7 degrees from the 70-yr mean weekly temperature. By the end of September, we were 200 growing-degree-days below the year-to-date 70-yr mean temperature. Thus, our susceptible check mean DI was 2-3 classes below the average of 6-7. Nevertheless, the procedure of throwing soil into the crowns provided adequate contrasts among entries. Mean DIs across all tests for highly resistant, resistant, and susceptible checks were 1.7, 1.8, and 4.2, respectively.

Testing of materials developed by R.J. Hecker.--L. Panella, E. G. Ruppel and R. J. Hecker (retired).

Genetic information developed previously in our research was used for additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our cyclic improvement program. Germplasms in various stages of improvement were evaluated for resistance in inoculated field tests. Results of these tests were the basis of decisions about specific germplasm, i.e., retain, shelve, discard, recombine, release, register, etc. Germplasms likely to be useful for variety improvement were identified and released for use by other sugarbeet breeders.

We are continuing to field-evaluate lines developed in the breeding program of Dr. R. J. Hecker. Thirteen lines were field-tested in 1993 for resistance to *Rhizoctonia solani*, *Cercospora beticola*, and the curly top virus (Table 1). Seed was increased from three lines, FC709(4X), FC710(4X), and FC712(4X), that were converted to tetraploidy (4X) with colchicine treatment. They are lines that previously were released from the Fort Collins program as diploids (2X), with good combining ability and high resistance to Rhizoctonia root rot. Additional lines developed in Dr. Hecker's program were increased in isolation plots in 1993.

Lines that showed outstanding performance in 1993 field trials will be released in 1994 or 1995. One of the tetraploids, along with a few other lines increased in 1993, will be tested in the summer of 1994 and the best of these lines released.

Base Populations to Develop Multiple Disease Resistance.--L. Panella.

In a hybrid crop like sugarbeets, it is preferable that all of the parents contain some level of resistance to diseases prevalent in the area in which the hybrid is to be grown. Multiple disease resistance is a difficult goal in a crop improvement program, especially when working with an outcrossing species. In alternating generations of selection, some of the progress made in resistance to one disease is lost while selecting for resistance to other diseases.

One way of solving the problem of selecting for multiple disease resistance is the use of progeny testing. By testing the progeny of individual mother roots, plants with multiple disease resistance can be identified and used as parents of the next generation. The most efficient use of progeny testing is when the genotype of both parents is known, and the easiest way to do this is through self-pollination. In sugarbeet, the dominant, self-fertility allele permits self-pollination. Used in conjunction with genetic male sterility to insure cross pollination, a system of full-sib progeny testing can be utilized.

Material from the USDA-ARS breeding program at Salinas, CA, has been crossed with some of the Fort Collins lines most resistant to *Rhizoctonia solani*. The Salinas material had the self-fertility allele, was segregating for genetic male sterility, and also contained a broad spectrum of resistance to diseases of importance in California as well as other sugarbeet production areas (including rhizomania, powdery mildew, virus yellows, curly top virus, and cyst nematode). Crosses were made reciprocally (with some plants from each line as females and some as males) when possible. The genetic male sterile plants in the Salinas lines were used as females, and red (R_) and green (rr) hypocotyl color were used

as markers (if possible) when the Fort Collins material was used as a female (♂ = R_ and ♀ = rr; only progeny with a red hypocotyl will be used). We also examined the possibility of using isozyme markers or RFLP markers when the plants with the correct hypocotyl color were not available.

Table 1. The performance in three disease nurseries of previously released Fort Collins (FC) germplasms and thirteen lines being considered for release.

		Disease indices		
Source	Designation	Curly top	Leaf spot	Rhizoctonia
921002HO	FC604	---	4.5	---
921002HO1	FC604CMS	---	3.8	---
911026HO	FC715	7.0	3.7	1.3
911026HO1	FC715CMS	6.3	3.5	1.0
911028	FC716	6.3	3.7	1.2
911031	FC717	6.7	4.0	1.0
911032	FC718	6.3	4.2	1.1
911037	FC719	5.7	4.2	1.2
931006HO		5.7	5.0	1.4
931006HO1		5.0	4.2	1.3
931007		5.3	4.2	1.3
921007		6.3	4.0	1.2
921008		5.7	4.3	1.2
921012HO		5.3	4.5	1.1
921012HO1		5.3	4.2	1.2
931010		6.7	3.5	1.2
921019		7.0	4.0	0.9
921021		6.3	3.5	1.0
921025		7.3	4.7	1.1
921022		6.3	3.7	1.2
921024		6.7	3.7	1.0
Susceptible check[1]		5.3	6.3	3.0
Resistant check[2]		4.7	4.5	1.2
Highly resistant check[3]				1.3
LSD		NS	1.1	0.4

[1]Susceptible check: curly top = US33, leaf spot = LSS synthetic, Rhizoctonia = 831044.
[2]Resistant check: curly top = US41, leaf spot = 821051H2, Rhizoctonia = FC703.
[3]Highly resistant check: Rhizoctonia = FC705-1.

Five lines from the Salinas breeding program, grown in the steckling field, were crossed with two lines from the Fort Collins program. Both multigerm pollinators

and monogerm, O-type maintainers were used (Table 2). Neither isozyme analysis nor the use of RFLPs, obtained from restricting the ITS region in the rDNA region (Figure 1), provided enough discrimination to distinguish hybrid progeny in the crosses between Fort Collins and Salinas material. This provides some indication of the lack of genetic diversity among cultivated sugarbeet populations used in this country.

Table 2. The parents to be used in reciprocal crosses to establish Rhizoctonia resistant base populations.

Line	Origin	Comments
FC708	Fort Collins	Rhizoctonia resistant O-type
921024	Fort Collins	Rhizoctonia resistant Multigerm
93A001	Salinas	2915, Multigerm segregating for self-fertility and male sterility
93A002	Salinas	R278, Multigerm, self-fertile segregating for genetic male sterility
93A003	Salinas	2890, segregating for O-type, self-fertility and genetic male sterility
93A004	Salinas	N244, Multigerm segregating for self-fertility and male sterility
93A005	Salinas	2859, O-type segregating for self-fertility and genetic male sterility

The Salinas lines from the steckling field will be crossed to the Fort Collins disease-resistant lines and the F_1 populations intracrossed ('selfed'). The resultant populations, together with the materials from Dr. Hecker's program, eventually will form the basis of a Rhizoctonia breeding project, containing a strong laboratory component. This program will focus on understanding the genetics of the *R. solani*-sugarbeet interaction, increasing selection efficiency for resistance to Rhizoctonia root rot, and producing multiple disease resistant sugarbeet germplasms.

Genetic Variation and Pathogenicity in Rhizoctonia solani.--L. Panella and M. K. Hjort.

Currently, it is possible to assay the pathogenicity to sugarbeet of an isolate of *R. solani* through a greenhouse bioassay only, which may take 12 to 16 weeks. Although there has been recent work done on the phylogenetics of this pathogen, evolutionary relationships among isolates have not been well correlated with the host specificity of the fungus. Whether the pathogenicity to sugarbeet has evolved once or more than once could substantially influence the types of host-pathogen interactions.

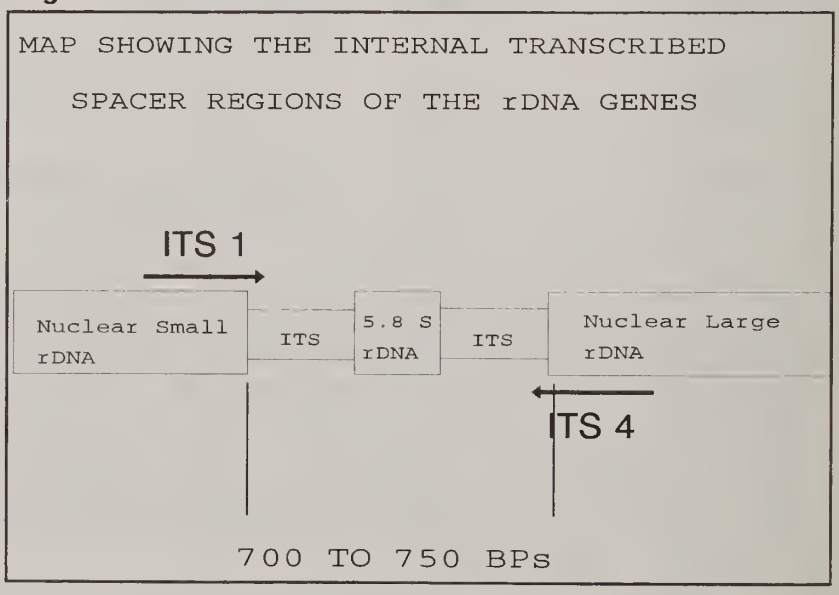
R. solani is divided into anastomosis groups (AGs) based on the ability of the hyphae to fuse and exchange genetic material, or, more recently, into

intraspecific groups (ISGs) based on molecular markers, especially the internal transcribed spacers (ITS) flanking the 5.8S ribosomal RNA gene (rDNA) (Figure 1). Isolates of *R. solani* from AG-4 cause seedling damping-off in sugarbeet, and isolates from AG-2-2 cause root and crown root in mature beets.

We are using PCR to amplify the DNA of *R. solani* coding for the 5.8S ribosomal RNA gene (rDNA) as well as the two flanking ITS regions. This will be done with the ITS1 and ITS4 primers (Figure 1) (Lee & Taylor, 1990). Restriction enzymes that recognize four base-pair sites are being used to create restriction fragment length polymorphisms (RFLPs) from the amplified DNA. We will use these RFLP markers to identify ISGs within AG-2-2. Isozyme markers may also be used to further discriminate ISGs. The *R. solani* isolates then will be tested for their virulence in sugarbeet. The phylogenetic information will be correlated with the pathogenicity data to see if all the isolates pathogenic to sugarbeet belong to the same evolutionary group. In any case, the sugarbeet-pathogenic group(s) will be delineated with genetic markers.

Currently, DNA from 42 isolates of *R. solani* has been amplified and cut with five restriction enzymes. Some RFLPs were detected with these enzymes, as well as initial differences in the size of the amplified length of DNA, which varies from approximately 700 to 750 base pairs (BPs).

Figure 1.



Forty to 60 more isolates of *R. solani* pathogenic to sugarbeet are being obtained from diverse locations. They will be analyzed in a similar fashion to the original 42. The DNA will be separated on agarose gels, visualized with ethidium bromide, and photographed. We will use the enlarged photographs to estimate the fragment sizes, using markers of known size (from a *Hae*III digest of ΦX174RFI). More enzymes will be used as needed to discriminate among the various ISGs in the different anastomosis groups. Greenhouse tests will be used to determine the pathogenicity of the isolates of *R. solani* to sugarbeet. These data will be correlated with the phylogenetic information.

Lee, S.B., and J.W. Taylor. 1990. Isolation of DNA from fungal mycelia and single spores. Pages 282-287, *in* M.A. Innis, D.H. Gelfand, J.J. Sninsky and T.J. White (eds.), PCR Protocols: A Guide to Methods and Applications. Harcourt Brace Jovanovich, San Diego.

EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO RHIZOCTONIA ROOT ROT (BSDF Project 903)

We used randomized complete-block designs with five replications to evaluate a total of 173 lines from six companies; additionally, one company had a second test of 12 lines replicated three times. Rhizoctonia resistant FC703 and highly susceptible FC901 were included as internal controls, along with highly resistant FC705-1. Experimental design, plot size, and evaluation method are described in the section "1993 Field Research on Rhizoctonia Root Rot of Sugarbeet." The experimental design, methods, results and statistical analyses were provided to the appropriate company breeders.

Our 1993 root rot epidemic was milder than normal due to a cool, wet summer, but more severe than in 1992. Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and highly susceptible FC901 were 1.7, 1.8, and 4.2, respectively, compared with 0.7, 0.8, and 1.3, respectively, in 1992. Percent healthy roots were 53.0, 49.2, and 8.9 for these controls, respectively; percentages of roots in disease classes 0 through 3 were 97.7, 98.0, and 60.3, respectively. The lowest and highest mean DIs for contributor lines across tests were 1.4 and 5.4, respectively, compared with 0.5 and 2.9 in 1992.

EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO CERCOSPORA LEAF SPOT (BSDF Project 904)

We used randomized complete-block designs with three replications to evaluate 214 lines from six contributors. Internal controls included a highly susceptible synthetic and a resistant check, FC(504 X 502/2) X SP6322-0. Two-row plots were 4.3 m (14 ft) long, with 56 cm (22 in) between rows and a 20- to 25-cm (8- to 10-in) within-row spacing. We inoculated twice (June 29 and July 7).

The 1993 leaf spot epidemic progressed slowly due to our cool summer (see "1993 Field Research on Rhizoctonia Root Rot of Sugarbeet," these reports). Although disease severity by early September was not as great as in previous years, we made our first evaluations on September 7. That afternoon, we had a short, but extremely hard hail storm, which was followed by two nights of severe frost. At our second rating date (September 14), the leaves were severely tattered from the hail, and there was much frost damage. I decided that further evaluations would be useless.

On September 7, means of the resistant and susceptible checks across the nursery were 2.7 and 4.4 (scale of 0-10), respectively. In 1992, these means on September 17 were 4.1 and 6.7. Means of contributor lines ranged from 2.0 to 5.0 on September 7, and 3.0 to 6.0 at the later date. In 1992, means on September 17 ranged from 3.2 to 7.3. Means of contributor tests were tabulated, statistically analyzed, and sent to the appropriate contributor.

SUGARBEET RESEARCH

1993 Report

SECTION D

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C. A. WOZNIAK, G. A. SMITH and L. G. CAMPBELL

PUBLICATIONS

Abstracts of Papers Presented, Published, or Approved for Publication

BUGBEE, W. M. 1993. *Rhizoctonia*-induced phytoalexin production in sugarbeet. *J. Sugar Beet Res.* 30:83.

Resistance of sugarbeet to *Rhizoctonia solani* increased with age. The shift from susceptibility to resistance occurred about three weeks after planting and was accompanied by the production of phytoalexins. Three-week-old plants produced more phytoalexin when infected by the AG 4 strain than when infected by the AG 2-2 strain of *R. solani*. At five weeks, more phytoalexin was induced by AG 2-2 than AG 4. AG 4 was more sensitive than AG 2-2 to phytoalexin, which may partially account for the avirulence of AG 4 on older plants. When root slices were inoculated with *R. solani*, more phytoalexin was produced by the susceptible cultivar Ultramono than the resistant germplasm FC 712. The AG 4 strain induced more phytoalexin than AG 2-2, but neither was significantly different than untreated controls. *R. solani* cultures with pectin from Ultramono as the only carbon source contained more phytoalexin elicitors than cultures of FC 712 pectin. AG 2-2 induced more elicitors than AG 4, but neither induced more than the uninoculated control. Pectic fragments appeared to be weak elicitors of phytoalexins. Thus phytoalexins were associated with age-related resistance but not varietal resistance. Pre-formed antibiotics were present in ethanol extracts of root.

CAMPBELL, L. G. and A. W. ANDERSON. 1993. Additional sources of resistance to sugarbeet root maggot. *Annual Plant Resistance to Insects Newsletter* 19:18.

Selection for resistance to the sugarbeet root maggot (*Tetanops myopaeformis* Röder) has been marginally successful. While it seems apparent that one can develop sugarbeet (*Beta vulgaris* L.) lines with a moderate and perhaps useful level of resistance, the difficulty of selecting under natural infestations and mode of inheritance hinder the incorporation of sugarbeet root maggot (SBRM) resistance into commercial hybrids. Because of this, new and more effective resistance genes are especially needed in the SBRM breeding program. The Sugarbeet Crop Advisory Committee (CAC) has sponsored a SBRM screening effort at St. Thomas, North Dakota since 1987. Data has been compiled on 170 accessions of the NC-7 *Beta* collection (USDA-ARS, Ames, Iowa) and is available on the USDA Germplasm Resources Information Network (GRIN). The following 17 accessions have been characterized as having at least an intermediate level of SBRM resistance and will be reevaluated: PI-165485, PI-232887, PI-266100, PI-266104, PI-274394, PI-285589, PI-285590, PI-285594, PI-286502, PI-293419, PI-355962, PI-357357, PI-467869, PI-467870, PI-467871, PI-467874, PI-467875. All 17 are biennials; nine are sugarbeet types and the remainder table

beets. The resistance of two accessions identified in an earlier screening, PI-179180 and PI-181718, has been confirmed. These two accessions incur damage similar to the most resistant lines in our breeding program. Crosses have been made to transfer this resistance into agronomically useful populations and to study the inheritance of resistance. The CAC screenings included species related to sugarbeet. Although only a few *B. patellaris* accessions have been examined, all exhibit a high level of resistance. Unfortunately, crosses between this species and sugarbeet are not easy.

CAMPBELL, L. G., A. W. ANDERSON, and K. A. PRODOEHL. 1993. The use of exotic and domestic germplasm for resistance to the sugarbeet root maggot. *J. Sugar Beet Res.* 30:84.

The sugarbeet root maggot (*Tetanops myopaeformis* Röder) is a major insect pest of sugarbeet (*Beta vulgaris* L.). Attempts to develop resistant genotypes have been marginally successful. Breeding lines provide control comparable to that obtained with insecticides. However, the difficulty of selection and the mode of inheritance make it difficult to incorporate maggot resistance into a commercial hybrid development program. Past breeding efforts have utilized mass selection under natural maggot infestations. Alternative methods being explored include selection based upon family performance and the conversion of resistant germplasm to a tetraploid line for testing as a pollinator parent. Portions of the NC-7 *Beta* collection (USDA; Ames, Iowa) have been screened for maggot resistance. PI179180 and PI181718 have confirmed resistance. Both are biennial with red globe-shaped roots. Seventeen biennial *B. vulgaris* accessions identified as resistant in initial screenings are being increased for further evaluation. A 0 to 9 damage rating scale was utilized to differentiate among breeding lines more efficiently than the widely used 0 to 5 scale.

CAMPBELL, L. G. and W. M. BUGBEE. 1994. Pre-breeding for root-rot resistance. *Proc., Third International World Beta Network Conference*, Fargo, ND, August 4-6, 1993.

A number of crown and root rot diseases reduce yield in sugarbeet. Many of these diseases are limited to small geographic areas and their incidence is often sporadic. Hence, development of resistant cultivars has not been a high priority. Rhizoctonia, Aphanomyces, and Erwinia root rots are exceptions. Commercially useful resistance to *Rhizoctonia* and *Aphanomyces* originated from only a few sources. *Erwinia* resistance is available from numerous sources and is relatively easy to select for. Selection for resistance to prevalent storage rot fungi is possible but has not received much attention from commercial sugarbeet breeders. Knowledge of the inheritance of root or storage rots is frequently incomplete and sometimes inconsistent. Results of systematic screenings of the USDA *Beta* collection confirm the scarcity of resistance to *Rhizoctonia* and *Aphanomyces* and the difficulty of broadening the currently narrow genetic base of sugarbeet. Genetic engineering techniques probably will not make a contribution to the development of root rot resistant germplasm in the near future. Understanding

the biochemical basis of resistance will eventually improve selection efficiency and hasten the application of genetic engineering technologies to the problems of host plant resistance.

CAMPBELL, L. G. and A. W. CATTANACH. 1993. Effects of a foliar applied cytokinin on sugarbeet. *J. Sugar Beet Res.* 30:83.

There have been numerous attempts to increase crop productivity through the manipulation of plant hormones. Although this research has encompassed a wide variety of crop species, environments, and objectives, growth regulator (hormone) usage remains minimal in field crop production; sugarbeet (*Beta vulgaris* L.) is no exception. Cytokinins are known to influence a number of plant processes including cell division and enlargement, suggesting an influence upon sugarbeet root size and sucrose concentration. Seven rates of a cytokinin containing plant growth regulator (TRIGGRR; Westbridge Agricultural Products, San Diego, CA) were applied to sugarbeets in the 2-, 4-, and 6-leaf stage. Root yield, sucrose concentration, and recoverable sucrose yield were measured in 1989-1991 field trials. Storage respiration rate and response to two storage rot fungi (*Phoma betae* (Oud.) Frank and *Botrytis cinerea* Pers. ex Fr.) were measured in 1990 and 1991. Field plots were established using conventional tillage practices in Cass County, ND. Significant year effects for all traits were a reflection of differences in growing season weather conditions. Recoverable sucrose yields in 1989 were 30% less than 1990 yields. Nonsignificant treatment effects for all traits suggested that either foliar applied TRIGGRR does not enhance sugarbeet productivity or that it should be applied differently. Nonsignificant year X application rate interactions for all characters indicated this response was consistent in all three years.

DONEY, D. L. 1993. Wild beet in Egypt. *J. Sugar Beet Res.* 30:89.

The wild beets of Egypt are considered to be some of the most primitive. Because of the long history of farming in Egypt, it was anticipated that few wild types would be found. On the contrary, many were found, due mainly to their use as a leaf vegetable by local farmers. Collections were made at selected locations scattered throughout the Delta area, west to Matruh, in the Fayyum area of Middle Egypt, and in the Luxor area of Upper Egypt. A more intensive collection effort was made around the Alexandria area. A total of 26 locations were sampled. Wild beets appear to be distributed throughout the Delta. They were more sparsely distributed in the Fayyum and Luxor areas, where farmers were found collecting and growing wild beets as a green vegetable. In these areas, the farmers are serving as a means of preserving the wild *Beta* germplasm; however, their actions may have exerted selection pressure for leaf type beets.

DONEY, D. L. 1994. Broadening the genetic base of sugarbeet. 1993. *Proc., Third International World Beta Network Conference*, Fargo, ND, August 4-6, 1993.

The narrow base from which sugarbeet originated, the need for disease resistance and the negative relationship between root yield and sugar accumulation have all contributed to make the current gene pool from which most present-day sugarbeets originate narrow. Of the wild germplasm available, *Beta vulgaris* subspecies *maritima* offers the greatest promise of broadening the genetic base for future sugarbeet improvement. Crosses between *B. maritima* and sugarbeet male sterile inbreds have been advanced through four successive cycles of mass selection for root shape. Two of these crosses are approaching sugarbeet in root shape, root yield and sucrose concentration; however, they are still below commercial sugarbeet hybrids in root yield and sugar concentration. Even though these populations are inferior to commercial sugarbeet hybrids, it is the author's belief that superior combining germplasm exists in some of this material and that combining these with commercial germplasm will produce superior hybrids. Additional populations (crosses between sugarbeet and regional populations of *B. maritima*) are in the developmental stage. Sugarbeet inbreds segregating for mendelian male sterility were used in the initial crosses to insure crossing and recombination in each selection cycle.

DONEY, D. L. and R. J. MARTENS. 1994. Selection for Delayed Leaf Senescence in Sugarbeet. *J. Sugar Beet Res.* (in press).

Sugarbeet growth is characterized by the continuous dying of old leaves and initiation of new leaves. If the photosynthetic activity of leaves can be extended, fewer leaves may be needed and more photosynthate can be translocated to the root for sucrose production. Two cycles of divergent selection for early and late senescence of the first leaf were conducted in a very heterogeneous population. Significant genetic changes in each direction were obtained for the green leaf duration of the first leaf. Populations produced from the two cycles of divergent selection were evaluated for their effects on canopy in replicated multi-harvest field trials. The early senescing populations had significantly more and smaller leaves than the late senescing populations but equal total leaf area. Root and canopy dry matter were not affected by selecting for extended leaf duration, but selection for reduced leaf duration reduced root dry matter and total dry matter accumulation.

EIDE, J. D. and G. A. SMITH. 1993. Characterization of pathogenesis related proteins in *Cercospora* leaf spot susceptible and resistant leaf tissue. *J. Sugar Beet Res.* 30:91.

Understanding the nature of *Cercospora* resistance on a molecular basis should certainly enhance our ability to control this destructive fungus. The PR proteins are known to be synthesized in response to *Cercospora* infection. The objective of this study is to determine the presence of these proteins and what roles they

play in *Cercospora* resistance. The PR protein chitinase was isolated from leaf spot susceptible (LSS) and resistant (LSR) leaf tissue. Chitinase activity was determined spectrofluorometrically by measuring 4-methyl-umbelliferone released from the substrate 4-methylumbelliferyl-β-D-N,N'-diacetyl-chitobiocide. Six-week-old sugarbeet LSR leaves had 138% higher levels of chitinase activity than LSS leaves. Chitinase from leaf tissue was purified using ammonium sulfate precipitation followed by a chitin affinity method. The apparent molecular weight of the chitinase was 34 kDa as determined by polyacrylamide gel electrophoresis. Purified chitinase extracts will be used to check for inhibition of *Cercospora* fungal growth.

SMITH, G. A. The theory of pre-breeding. 1994. *Proc., Third International World Beta Network Conference*, Fargo, ND, August 4-6, 1993.

Population changes and their dependent gene frequencies are affected by mutation, selection, random fluctuations, meiotic drive, and migration. The effects of selection pressure on relatively small populations can have dramatic effects on gene frequency and hence on breeding progress. This selection, driven by necessity, has resulted in "narrow base" sugarbeet populations. This paper presents examples of population changes which can occur (have occurred in sugarbeet) in populations subject to intense selection. The utility of gene frequency analysis and its use as a predictive tool is outlined. Sugarbeet breeders, geneticists, and agronomists now attempting to collect and introgress wild germplasm into breeding populations will be aided by attention to principles presented in this paper.

SMITH, G. A., C. A. WOZNIAK, L. G. CAMPBELL, and J. D. EIDE. 1993. Evaluation of entomopathogenic nematodes for control of *Tetanops myopaeformis*, the sugarbeet root maggot. *J. Sugar Beet Res.* 30:116.

Nematodes which attack insects (not to be confused with those that affect plants) may offer a biological control for the sugarbeet root maggot (SBRM). They have a broad host range, can be easily mass produced, possess the ability to seek out and rapidly kill their host, are environmentally safe, and have been exempted from registration by the U.S. Environmental Protection Agency. The soil offers an excellent site for insect-nematode interaction, and soil is the natural reservoir of steinernematid and heterorhabditid nematodes. To determine the feasibility of potential nematode use for control of the sugarbeet root maggot, we asked the following: (1) Will nematodes infect the SBRM? (2) Will nematodes reproduce following infection? (3) Can nematodes be applied in the field and be infective? (4) If nematodes are infective in the field, how long will they persist? (5) Will nematodes infect and reproduce in adult flies? We evaluated six strains of nematodes in the laboratory and found that all strains infected, killed, and reproduced in the SBRM larvae. Mortality of the root maggots ranged from 50 to 85 percent in the laboratory. Death of the larvae occurred 24 to 48 hours after

nematode infection. Reproduction within the larval cadavers produced several thousand infective juvenile nematodes 12 to 14 days after infection. Our first-year field tests, conducted in the summer of 1992, indicated that all strains tested infected the larvae in the field. Further laboratory tests determined that adult flies were infected after only two hours of exposure to the nematodes and that reproduction did take place in adult fly cadavers. The results of our investigation show the potential of pathogenic nematodes as a biological control agent for SBRM.

WOZNIAK, C. A. 1993. Influence of native microflora on *in vitro* larval development of *Tetanops myopaeformis* Roder (Diptera:Otitdae). *Proc. North Central Branch Mtg. Ent. Soc. Amer.*, p. 47.

Transmission of endogenous bacteria between generations of the sugarbeet root maggot (SBRM) is via externally carried microflora. Bacteria are transferred to the surface of the chorion during oviposition and transmitted to the first instars upon emergence from the egg sheath. Eggs treated with 0.2% hypochlorite were found to produce gnotobiotic larvae when reared on Luria-Bertani agar or Murashige and Skoog (MS) plant tissue culture medium. Gnotobiotic larvae coincubated on MS medium with axenic sugarbeet cells or roots were observed to feed on the tissue but failed to moult or increase in size. Death of these larvae typically ensued in less than 50 days, at which point they remained as first instars. Addition of *Xanthomonas maltophilia* (Xm), a bacterium isolated from natural populations of SBRM, at the onset of the coincubation with sugarbeet cells resulted in up to 50% of the larvae reaching the second or third instar stage. At the termination of the culture period, the relative amount of remaining sugarbeet tissue was greatly decreased in the presence of Xm and SBRM versus gnotobiotic SBRM. Comparisons of other isolates of Xm and other bacterial species suggests that the capacity to enhance insect utilization of the sugar beet cells is not limited to this one strain of Xm. This coincubation method may eventually serve as a production method for this maggot as they have been recalcitrant to routine lab rearing.

WOZNIAK, C. A. 1993. Culture of sugarbeet root maggots in sugarbeet cell cultures. *Annual Plant Resistance to Insects Newsletter* 19:18-19.

Axenic root cultures of sugarbeet cultivars 'REL-1', 'H5135' and 'MONOHI' were evaluated for their ability to support *in vitro* growth of gnotobiotic sugarbeet root maggots, *Tetanops myopaeformis* Roder (SBRM). 'REL-1' and 'H5135' were also tested as hairy root transformants resulting from transformation of hypocotyl explants using Agrobacterium rhizogenes. Surface disinfested SBRM eggs were allowed to hatch in the presence of these root cultures on Murashige and Skoog (MS) tissue culture medium. Many first instars survived longer than four weeks but all failed to moult. Similarly, first instar SBRM cultured on axenic suspension cells of 'REL-1' or 'EL48' were observed to feed and grow but

few (8%) moulted. Those advancing to the second instar stage soon succumbed without further development. Addition of *Xanthomonas maltophilia* (Xm), isolated from SBRM third instar larvae, enhanced moulting percentage to 35% of the total, and several larvae reached the third and final instar stage. This bacterium survived on MS medium in the presence of sugarbeet cells but grew very slowly on this minimal medium. The amount of remaining sugarbeet tissue following incubation in the presence of SBRM and Xm was greatly reduced compared to SBRM cocultured with sugarbeet cells only.

WOZNIAK, C. A. and S. E. HINZ. 1993. Native bacterial flora and development of larvae of the sugarbeet root maggot. *J. Sugar Beet Res.* 30:123.

Collections of third instar sugarbeet root maggots (SBRM), *Tetanops myopaeformis* Röder, were made in 1991 and 1992 from the Red River Valley, eastern Montana, north central Wyoming, and western Nebraska to determine the identity of bacteria associated with this larval stage. The most commonly encountered species were *Serratia marcescens*, *S. liquefaciens*, *Pseudomonas fluorescens*, *Ps. putida*, and *Xanthomonas maltophilia*. Of these, *X. maltophilia* (Xm) was the only species encountered consistently from third instars regardless of origin. Additionally, Xm was found to be a commensal of the sugarbeet rhizosphere. Bacteria naturally associated with SBRM are transferred to the surface of the chorion during oviposition and transmitted to the first instars upon emergence from the egg sheath. Eggs treated with 0.2% hypochlorite were found to produce gnotobiotic larvae. Gnotobiotic larvae coincubated on MS plant tissue culture medium with axenic sugarbeet cells were observed to feed on the tissue but failed to moult or increase in size. Death of these larvae typically ensued in less than 50 days, at which point they remained as first instars. Addition of Xm (isolated from natural populations of SBRM) at the onset of the coincubation with sugarbeet cells resulted in up to 50% of the larvae reaching the second or third instar stage. At the termination of the culture period, the amount of remaining sugarbeet tissue was greatly decreased in the presence of SBRM with Xm versus gnotobiotic SBRM without Xm. Comparisons of other isolates of Xm and other bacterial species suggests that the capacity to enhance insect utilization of the sugarbeet cells is not limited to this one strain of Xm. This coincubation method may eventually serve as a production method for this maggot as they have been recalcitrant to routine lab rearing.

WOZNIAK, C. A. and L. D. OWENS. 1994. Use of β-glucuronidase (GUS) as a marker for transformation in sugarbeet. *Proc., Third International World Beta Network Conference*, Fargo, ND, August 4-6, 1993.

Accurate detection of an introduced genetic or biochemical marker into sugarbeet (*Beta vulgaris* L.) is based on the absence of native sequences or activities in the plant that could confound the analysis of the introduced marker expression. During the course of experiments designed to optimize DNA transfer from

Agrobacterium tumefaciens to sugarbeet leaf disc cells, an endogenous enzyme activity was discovered which utilizes all the common substrates recognized by the marker enzyme, β-glucuronidase (GUS) from *E. coli*. This native sugarbeet enzyme (SB-GUS) was characterized immunologically and biochemically. GUS and SB-GUS were found to be distinct with regard to pH optima, thermal inactivation, reaction to denaturants and protein modifying reagents, inhibition by metals and saccharo-lactone, and molecular mass. The two activities are not immunologically related, as judged by Western blot and immunoprecipitation analyses. A protocol was developed to accurately quantitate introduced GUS in the presence of SB-GUS, by utilizing selective inhibition of GUS at pH 7.0 by saccharic acid 1,4-lactone. Under these conditions GUS activity is completely eliminated, while SB-GUS activity was unaffected.

WOZNIAK, C. A. and L. D. OWENS. 1994. Native β-glucuronidase activity in sugarbeet (*Beta vulgaris* L.). *Physiologia Plantarum* (in press).

β-Glucuronidase activity, initially thought absent from plants, has been found in a variety of plant families. During an analysis of Agrobacterium-mediated transformation of sugarbeet (*Beta vulgaris* L.), significant glucuronidase activity was observed in control (non-transformed) tissues when the fluorogenic substrates 4-methylumbelliferyl-β-D-glucuronic acid, resorufin glucuronic acid and 3-carboxyumbelliferyl-β-D-glucuronic acid were used to quantify beta-glucuronidase activity under standard protocol conditions. Similarly, the colorigenic substrate p-nitrophenyl-beta-D-glucuronide was hydrolyzed by this sugarbeet-derived glucuronidase. Biochemical and immunological data are presented to indicate significant differences between sugarbeet-derived glucuronidase and that of microbial origin (i.e., encoded by gus A; E.C. 3.2.1.31). These differences provide a means of distinguishing the two activities in extracts that contain a mixture of both. Use of X-gluc, the substrate utilized in histochemical localizations of glucuronidase activity, gave no positive reaction products (i.e., indigo precipitate) at pH 7.0. However, at pH 3.0, 4.0 and 5.0, formation of the indigo precipitate was evident within 1 h at 37°C in sugarbeet callus and by 4 h in leaves and petioles. The specific activity of SB-GUS was observed to be strongly pH dependent, with an optimum near pH 4.0. The use of β-glucuronidase techniques as applied to transformation of sugarbeet is discussed.

WOZNIAK, C. A., G. A. SMITH, and L. G. CAMPBELL. 1993. Entomopathogenic nematodes for control of larvae and adults of the sugarbeet root maggot (Diptera: Otitidae). *Proc., Beltsville Symposium Biologically Based Technologies of Pest Control*, p. 40.

Entomopathogenic nematodes were evaluated for their ability to infect and reproduce within third instar sugarbeet root maggots (SBRM). Six strains of *Steinernema* representing three species and four strains of *Heterorhabditis bacteriophora* were all capable of infecting and reproducing within third instar SBRM in vitro. Incubation of nematodes at field rates of three billion/acre for

72 h at 24 C resulted in infection and subsequent reproduction of infective juveniles (IJs) within SBRM cadavers. Egress of IJs was observed at 14-21 days post-incubation. Field testing of the six steinernematids indicated that all were capable of infecting SBRM larvae under a typical sugarbeet cropping system. Nematodes were observed to remain viable in soil, as measured by trapping with *Galleria* larvae, for at least two months following application. Adult flies were also found to be susceptible to all six steinernematids tested. *S. glaseri* was found capable of infecting adult SBRM with as little as 2 h coincubation over filter paper containing IJs. Egress of nematodes was observed at 5-6 days post-incubation. Following challenge of diapaused third instar SBRM with steinernematids, pupae were observed to form at an enhanced rate relative to controls. Emerging imagos were found to consist of 25% aberrant individuals. Aberrants had vestigial or absent wings, reduced sclerotization, poor body segmentation, misshapened head capsules and unretracted ptilina. No evidence of nematode infection was observed with these aberrants. They failed to produce eggs when mated to normal flies.

WOZNIAK, C. A., G. A. SMITH, D. T. KAPLAN, W. J. SCHROEDER, and L. G. CAMPBELL. 1993. Mortality and Aberrant Development of the Sugarbeet Root Maggot (Diptera:Otitidae) After Exposure to Steinernematid Nematodes. *Biological Control* 3:221-225.

Third instar larvae of the sugarbeet root maggot (*Tetanops myopaeformis* von Röder) were challenged *in vitro* with three strains of *Steinernema carpocapsae* (Weiser), two strains of *S. feltiae* (Filipjev), and one strain of *S. glaseri* (Steiner). Three larvae were incubated in each well of a polystyrene dish containing 5 g of autoclaved coarse sand with 500 μl of normal saline containing 270 infective juveniles. Larvae and nematodes were co-incubated at 24°C for 72 h in the dark. Larvae were then rinsed with distilled water and transferred to plaster mounts for observation. Infectivity readings were taken at 14 and 21 days post-challenge. *Steinernema carpocapsae* 'SCANMASK' showed the lowest level of infectivity, followed in ascending order by *S. carpocapsae* 'ALL', *S. carpocapsae* '252', *S. glaseri* '326', *S. feltiae* 'SN', and *S. feltiae* 'UK'. In several of the nematode challenges of diapaused larvae, resulting pupae gave rise to adult flies with gross abnormalities. Microscopic examination of these pupae gave no indication of nematode infection or an ensuing septicemia. Overall, 24.4% of the imagos arising from nematode-challenged larvae gave rise to aberrant adults. We have attributed these aberrant adults to an accelerated metamorphosis. These aberrant flies did not produce eggs, although mating attempts were observed.

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CERCOSPORA LEAF SPOT AND BIOPESTICIDE RESEARCH

G. A. Smith and J. D. Eide

BSDF Projects 600 and 601

Development of *Cercospora* Resistant Breeding Lines. Twenty breeding lines were evaluated at the ARS Fort Collins nursery in 1993. These again included several advanced multigerm leaf spot resistant lines intended for eventual release. The lines of most interest were equal to the resistant check. The 1993 leaf spot epidemic at Fort Collins was not considered reliable, thus these lines will be retested in the 1994 nursery.

Examination and Purification of Chitinase in Cercospora Leaf Spot Resistant Germplasm. Sugarbeets synthesize the pathogenesis related (PR) protein chitinase in response to fungal attack. This enzyme degrades the chitin found in fungal hyphae. We have previously shown that chitinase is expressed at higher levels in resistant lines than susceptible lines (see 1992 Sugarbeet Research Report). We are now purifying leaf chitinase proteins by homogenization, centrifugation, heat treatment, and ammonium sulfate fractionation. The activity in the ammonium sulfate fraction was 15.5 units. Protein concentrations were reduced from 235 mg to 17.45 mg. Electrophoresis of the fractions yielded enrichment of proteins with an apparent molecular weight of 26 to 30 kD. Additional purification by Q Sepharose FF chromatography separated the acidic from the basic and neutral proteins. Further affinity, PBE 94 and Mono P HR will be necessary to purify the chitinases to homogeneity before antibody production can begin. Antibody preparation can be used as a tool for detection of elevated chitinase levels in the plant using ELISA techniques. A simple antibody ELISA test can then be used to screen seedlings for high chitinase levels.

Vectors for Delivery of Biological Control Agents for the Sugarbeet Root Maggot. We are looking for a suitable vector for delivery of a gene or gene product active against the sugarbeet root maggot. A suitable vector for delivery of a biocontrol agent must be able to colonize the roots, be nonpathogenic, and be neutral or growth promoting. We have identified thirteen rhizobacteria from hundreds in our collection that are antifungal to *Aphanomyces cochliodes*, *Botrytis cinerea*, *Cercospora beticola*, *Phoma betae*, *Pythium ultimum* and *Rhizoctonia solani*. These bacteria were tested for effect on sugarbeet seedling growth. Treatments consisted of drenching the sugarbeet seedlings seven days after planting with 1×10^{10} bacteria per ml or vacuum infiltration of seed with 1% sodium alginate solution containing 1×10^{10} bacteria per ml. Plants were greenhouse grown and harvested one month after planting.

Results. *Enterobacter* treatments had the greatest fresh weight but were not significantly different from the control. The treatment with *Klebsiella* produced the only plants with significantly lower fresh weights (Fig. 1). Plants from the seed treatment had significantly lower fresh weights than the drenched seedlings (Fig. 2). We are presently testing the viability and longevity of the bacteria on the vacuum infiltrated seed.

Seeds vacuum infiltrated with antifungal rhizobacteria were tested for protection of seedlings in *Rhizoctonia*-infested soil. Vanderhave hybrid 66156 seeds were vacuum infiltrated with 1 X 10^{10} bacteria per ml in 1% sodium alginate for 1 h. The slurry was agglutinated with 0.1 M calcium chloride and allowed to dry in a fume hood overnight. Soil mix was infested with 100 CFU of *Rhizoctonia solani* AG-4 or 59-2. The experimental design was a split plot with 5 replications and 14 treatments. The subplots consisted of soil mix treated with *Rhizoctonia* AG-4, 59-2 or untreated mix. Five seeds were planted in 3-inch square pots containing the soil mix. The experiment was conducted in the greenhouse. Stand counts were taken at three weeks. The treatments were: 1 = *Flavimonas oryzihabitans*, 2 = *Pseudomonas fluorescens*, 3 = *Enterobacter taylorae*, 4 = *Enterobacter agglomerans*, 5 = unknown, 6 = *Pseudomonas fluorescens* a, 7 = *Pseudomonas aurantiaca*, 8 = *Serratia liquefaciens*, 9 = *Pseudomonas aurantiaca*, 10 = control (no bacteria), 11 = *Klebsiella terrigena*, 12 = *Serratia liquefaciens*, 13 = *Serratia liquefaciens*, 14 = *Pseudomonas fluorescens*.

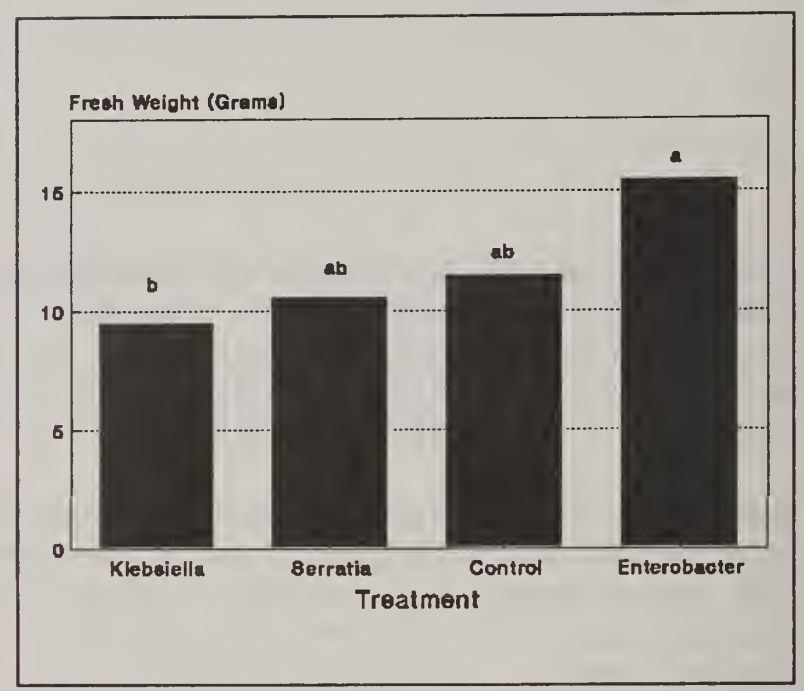

Figure 1 The mean fresh weights of 4-week-old sugarbeet plants treated with different antifungal rhizobacteria. Bars with the same letters are not significantly different according to Duncan's multiple range test (P=0.05).

Seedlings treated with *Pseudomonas* (treatment 14) and *Serratia* (treatment 13) gave the greatest protection to seedlings though not significantly different than the control (treatment 10) (Fig. 3). *Flavimonas* (treatment 1) provided a significantly lower level of protection than nine other treatments including the control. The use of these naturally occurring antifungal bacteria may help control seedling diseases and be a suitable gene vector against the sugarbeet root maggot. We are continuing to look at different rhizobacteria, delivery conditions and other seedling-associated microbes and their effects on sugarbeet seedling growth.

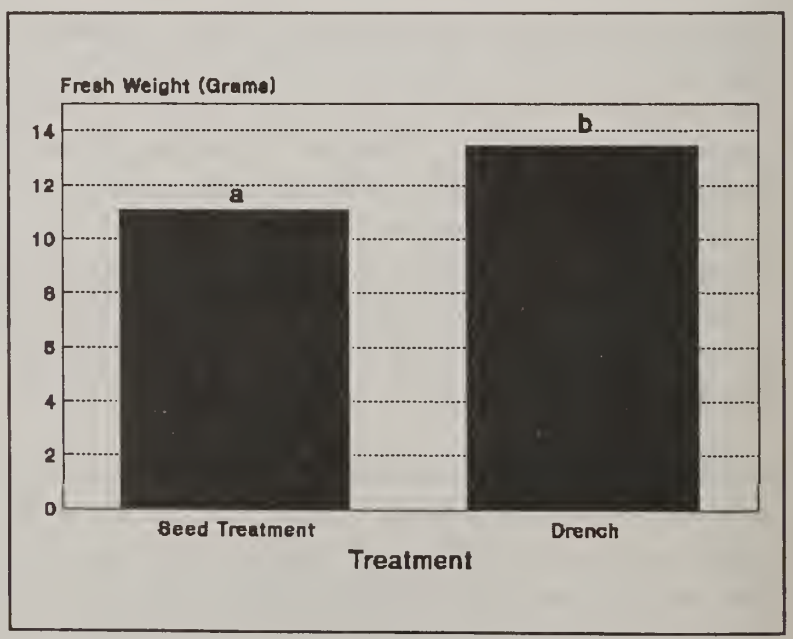

Figure 2 The mean fresh weight of 4-week-old sugarbeet plants treated with antifungal rhizobacteria by vacuum infiltration of seed or by drenched seedlings seven days after planting.

Transformation of Sugarbeet by Agrobacteria. Agrobacteria-mediated transformation is one method for delivery of a biopesticide gene product to the sugarbeet chromosome. Sugarbeet-associated *Agrobacterium* and type strains were tested for virulence on sugarbeet, sunflower and tobacco. Strain A281 formed the largest galls on sugarbeets. Total DNA from Agrobacteria were tested for the presence of the *virG* using polymerase chain reaction (PCR). None of the sugarbeet-associated *Agrobacterium* contained the 540 base pair fragment associated with the presence of *virG*. Bacteria not containing *virG* were eliminated from our sugarbeet transformation program. We are continuing to look for highly virulent Agrobacteria for use in our transformation program.

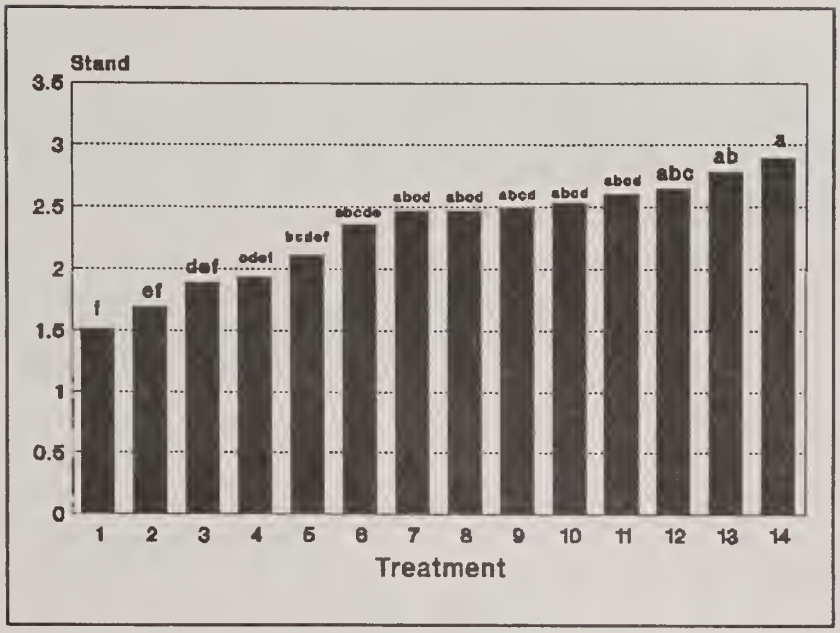

Figure 3 Sugarbeet stands three weeks after planting in soil mix with 100 CFU of *Rhizoctonia solani* AG-4 or 59-2. The seed had been treated with bacteria previously identified as antifungal.

Biological Control of Sugarbeet Root Maggot. A biological control method is being formulated to control the sugarbeet root maggot (SBRM) (*Tetanops myopaeformis*). As yet another leg of this program, we are examining the entomopathogenic fungi *Beauveria bassiana* as a control agent. The benefit of this sporulating fungi is that primary infected maggots would amplify inoculum and be available to infect other maggots.

Third instar sugarbeet root maggots were inoculated with 3×10^4 or 2.3×10^7 *B. bassiana* spores or conidia per ml of buffer. Mortality ranged from 5.4 to 23.6% after seven days and to a high of 54.5% after 29 days (Fig. 4). The *B. bassiana* was isolated from the infected third instar maggots and used to reinfect maggots. This satisfied Koch's postulates. We are presently testing *B. bassiana* and *Metarhizium anisopliae* on the first instar SBRM. We have obtained infection with both *B. bassiana* and *M. anisopliae* in eight days. We are presently isolating, purifying and

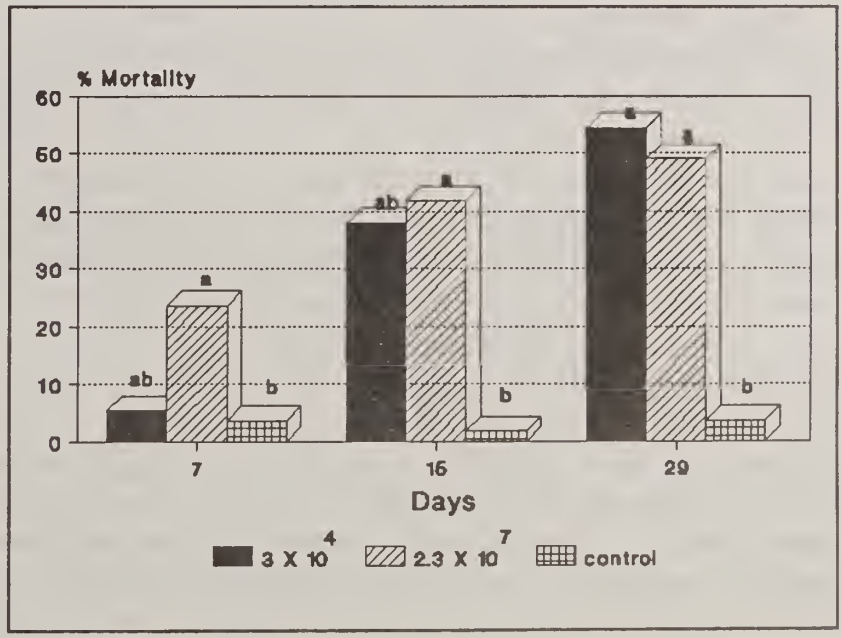

Figure 4 Mortality of third instar sugarbeet root maggots inoculated with *Beauveria bassiana*.

identifying these isolates and attempting to reinfect first instar larvae to satisfy Koch's postulates. We also plan to test infectivity on adult flies. These fungal pathogens may complement our nematode and/or *Bacillus thuringiensis* biocontrol methods, with the added caveat of infecting first and/or second instar larvae. *B. bassiana* will be tested at two field locations in the summer of 1994.

UTILIZING HOST RESISTANCE MECHANISMS AGAINST *RHIZOCTONIA SOLANI*

W. M. Bugbee

BSDF Project 610

Germplasm lines of sugarbeet (*Beta vulgaris* L.) with resistance to *Rhizoctonia solani* Kühn (teleomorph = *Thanatephorus cucumeris* (Frank) Donk) have been developed and are being used by private breeders as sources of root rot resistance for proprietary cultivars. Efforts to gain higher levels of resistance might be possible if we had a better understanding of the interaction between *R. solani* and sugarbeet. One component of the association is the variable aggressiveness among anastomosis groups (AG) of *R. solani* isolates. Seedling disease is caused by members of both (AG) 2-2 and 4 but, in general, isolates of AG 4 are much less aggressive than AG 2-2 on older plants. Factors that are suspected or have been shown to affect aggressiveness of fungal pathogens are their ability to produce pectolytic enzymes, the suppression of pectolytic enzyme production by sugars, and sensitivity to phytoalexins.

The phytoalexins, betagarin and betavulgarin, are produced in sugarbeet in response to *Cercospora beticola*. Recently, these two phytoalexins plus a third were shown to be produced by sugarbeet roots in response to infection by *R. solani*, but the authors did not report what effect the phytoalexins had on *R. solani*. Therefore, the role of sugarbeet phytoalexins in the aggressiveness of the fungus as a sugarbeet pathogen is unknown.

We reported that an AG 2-2 strain of *R. solani*, pathogenic on sugarbeet, produces pectin lyase (PNL) and exopolygalacturonase (exoPG) in culture and in rotted tissue. PNL was associated more with diseased roots than exoPG. We proposed that a constitutive, cell wall bound, pectin lyase inhibitor protein (PNLIP) is part of the sugarbeet's root rot resistance mechanism. To what extent the aggressiveness among isolates of *R. solani* is affected by PNLIP also is unknown.

To gain a better understanding of factors that might influence the aggressiveness of *R. solani* toward sugarbeet, isolates of AG 2-2 and AG 4 from wide geographic areas were examined for their sensitivity to phytoalexins, production of PNL and exoPG, sugar suppressiveness of pectinase production, and their susceptibility to PNLIP.

Discussion of Results. Sugar suppression of PNL production and the ability of the fungus to produce PNL appear to be more important root rot factors than the sensitivity to PNLIP or

accumulated phytoalexins. Although the two most aggressive isolates of AG 2-2 were more tolerant to phytoalexin than the less aggressive isolates, the response was not consistent because two isolates of AG 4 that did not cause disease were just as tolerant to phytoalexins. Therefore, sensitivity to phytoalexins was not consistently associated with root rot when considering both AGs. The limited role of phytoalexins in disease resistance is recognized. Some of these limitations evidently exist in this *Rhizoctonia*-sugar beet association. If phytoalexin production by infected sugar beets has a major role in biochemical resistance, the effect was not sufficient to account for the inability of the AG 4 isolates to cause disease on older roots.

The absence of root rot consistently was associated with an isolate's inability to produce sufficient amounts of PNL and its susceptibility to sugar suppression of PNL production. Two isolates of AG 2-2 had low aggressiveness, and three of the four isolates of AG 4 were not able to cause root rot. These isolates produced significantly less PNL and their PNL production was suppressed further by sugars compared with the more aggressive isolates of AG 2-2. Altered aggressiveness caused by sugar suppression of pectolytic enzyme production has been reported before. Others have shown that glucose, fructose, sucrose and other sugars decreased the aggressiveness of *R. solani* on cotton seedlings through suppression of pectolytic enzyme production. The aggressiveness of *Fusarium oxysporum* f. sp. *cepae* on onion was related to the suppression of PNL by sugars that had accumulated in tissues. Mean sucrose content of roots assayed in this study was 7% by weight (69 μg/mg) and would reach 16 to 18% under normal field conditions, while sugars in petioles were only 0.1 to 2%. The sucrose level in roots would be sufficient to suppress PNL production by *R. solani*. The aggressiveness of AG 4 isolates on seedlings, but not on older plants, may be related to the content of sugars in young plants. The sugar content in seedlings might not be enough to suppress pectolytic enzyme production so the fungus is able to cause disease. Therefore, efforts to enhance early sucrose accumulation in seedlings might improve resistance to *R. solani*.

The effectiveness of PNLIP was not associated with differential aggressiveness among the isolates tested here. When the ratio of PNLIP to PNL was high enough, complete inhibition of PNL occurred. For this reason, the inhibition of PNL activity, and hence aggressiveness of *R. solani* might be correlated with the PNLIP content in cell walls. Therefore, manipulation of the gene that encodes PNLIP and the transformation of sugarbeet to overproduce PNLIP should enhance the host's resistance by suppressing the activity of PNL. Reduction of PNL activity by elevated PNLIP levels would complement the sugar-suppression of PNL production that apparently already exists in sugarbeet roots.

Manipulation of a Root Rot Resistance Factor. The strategy is to identify an important biochemical mechanism of pathogenesis in the pathogen and then to identify complementary resistance mechanisms in the sugarbeet. If resistance factors can be easily detected, or easily manipulated at the molecular level, then sugarbeets with high levels of the factor could be identified in the greenhouse or created in the laboratory. This approach complements the current, labor-intensive, field method of developing *Rhizoctonia*-resistant germplasm. A positive correlation of high levels of a known resistance factor with root rot resistance would provide the impetus for a novel, more efficient breeding program.

Results. We have shown that the aggressiveness of *R. solani* toward sugarbeet is due largely to the amount of PNL that is produced by the fungus. PNL is a cell-destroying enzyme. The sugarbeet produces PNLIP as part of its resistance arsenal. Plants with high levels of PNLIP might also have elevated root rot resistance. We have used polyclonal and monoclonal antibodies against purified PNLIP in a double antibody sandwich enzyme-linked immunoassay (DAS-ELISA) to detect PNLIP in sugar beet extract. Out of < 1600 greenhouse-grown, three-month-old plants that were assayed, several individuals with high PNLIP values were selected and induced to flower. Tissue cultures were initiated from axillary buds of the selections to produce clones. The selected plants are from: 1) F1001, a germplasm line with resistance to *Phoma betae*, a storage rot pathogen that was selected from a Russian introduction; 2) F1010, a high sucrose germplasm line from an interpollinated population of individuals from the world collection; 3) 75B7, a germplasm line with resistance to *Botrytis cinerea* that was developed from another Russian introduction; and 4) 768, a germplasm line with resistance to *P. betae* also selected from a Russian introduction. The intent is to cross these clones to generate synthetic lines and then to evaluate them for resistance to *R. solani*.

Toward Cloning and Sequencing a Root Rot Resistance Gene. The objective here is to clone the sugarbeet gene that is responsible for the production of PNLIP and then to manipulate this gene to overproduce the PNLIP under the assumption that plants with very high levels of PNLIP will be more resistant to Rhizoctonia root rot.

mRNA was purified from sugarbeet leaf tissue and used to produce cDNA. A cDNA library was generated in *Escherichia coli* using the plasmid pcDNAII (Invitrogen Corp.) as the vector. The library was probed with an antibody to PNLIP but no clones producing PNLIP were detected. A second library was produced using mRNA from sugarbeet root. Several transformed colonies of *E. coli* were positive when lysates were probed with a polycolonal antibody. These clones are being evaluated for synthesis of PNLIP.

BROADENING THE GENETIC BASE OF SUGARBEET
(Pre-breeding)

D. L. Doney

BSDF Project 630

Continued sugarbeet improvement is dependent on the availability of desirable genetic variation. The genetic background from which most present day sugarbeet cultivars originated is considered by most sugarbeet breeders to be narrower than that for other cross-pollinated crops. There appears to be sufficient genetic variability for cultivar improvement in the short term; however, long term improvements may be impeded if significant infusions of new and/or additional genetic variability are not made.

The primary objective of this research is to develop near-sugarbeet type populations containing new genetic variability for use in elite sugarbeet breeding pools. Secondary objectives include

the development of selection criteria that are effective in creating near-sugarbeet type populations.

Near-sugarbeet Selections. Individual family lines derived from a cross between sugarbeet inbred L53 and wild beet accession PI 546420 were tested for combining ability in 1993. L53 is a self-fertile, O type, multigerm inbred with high general combining ability for root yield. PI 546420, *Beta vulgaris* subspecies *maritima*, was collected near Thessaloniki, Greece by C. Goulas in 1978. It is multigerm, annual and prostrate in growth habit.

These family lines resulted from four cycles of mass selection for root shape. By the third cycle, roots were beginning to look like sugarbeet roots. For each cycle, all selected plants were randomly intercrossed in open-pollinated isolation cages and, except for cycle four, harvested in bulk. In cycle four, seed was harvested from each plant and maintained as individual family lines. Annuals were eliminated in the early cycles. Family lines from cycle four were crossed to sugarbeet inbred L33cms for combining ability analyses. The resulting crosses along with the respective family lines were tested in replicated field trials in 1993 (Tables 1 and 2).

Table 1. Root yield, sucrose percentage and sugar yield for eight family lines and their respective test cross and the mean of two commercial hybrid checks.

Family line	Root yield		Sucrose		Sugar yield	
	Line T/A	Test cross T/A	Line %	Test cross %	Line LB/A	Test cross LB/A
x115-1	8.0	16.3**	14.1	14.1	2241	4934**
x115-4	14.9	16.0	13.0	13.8	3892	4403
x115-6	10.8	15.2**	14.8	14.9	3190	4527**
x115-7	10.2	19.7**	14.8	14.7	3045	5798**
x115-9	11.9	16.1**	13.0	13.9*	3299	4427**
x115-10	16.6	17.6	13.0	14.2*	4291	5419**
x115-11	13.2	17.9**	12.9	13.6	3407	4853**
x115-13	15.3	22.3**	12.3	13.5*	4069	5963**
Commercial Hybrids		20.5		15.0		6170
LSD 0.05		3.3		0.9		688

*, ** = Test cross significantly greater than the family line at $P = 0.05$ and $P = 0.01$, respectively.

Table 2. Root yield, sucrose percentage and sugar yield for seven family lines and their respective test crosses and the mean of two commercial hybrid checks.

Family line	Root yield		Sucrose		Sugar yield	
	Line T/A	Test cross T/A	Line %	Test cross %	Line LB/A	Test cross LB/A
x115-14	7.7	16.3**	13.5	14.1	2076	4598**
x115-18	15.6	17.7	14.3	14.4	4466	5088
x115-19	10.9	17.4**	13.7	14.2	2921	4918**
x115-20	9.5	16.6**	12.9	13.7*	2451	4537**
x115-22	8.4	18.6**	13.9	14.0	2322	5200**
x115-26	11.8	18.2**	12.3	13.6*	2815	4956**
x115-28	12.5	19.8**	13.0	14.0*	3245	5550**
Commercial Hybrid		19.9		15.1		6036
LSD 0.05	2.7			0.8		
763						

*, ** = Test cross significantly greater than the family line at $P = 0.05$ and $P = 0.01$, respectively.

All but three of the family lines tested showed significant heterosis for root yield and sucrose yield (test cross vs. family line). Only those with low sucrose percentages showed a significant increase in sucrose percentage in the test cross. Several of the test crosses are approaching the commercial hybrids in root and sucrose yield (Tables 1 and 2). There were no differences in sodium, potassium and amino nitrogen between the test cross and parent line nor between the family lines and the hybrid checks (data not shown). All but two of the family lines had tare ratings very similar to the hybrid checks, suggesting that the root types were very similar to sugarbeet and generally void of sprangling. Several of these lines will be released to the industry for use in elite breeding pools.

New Populations. New populations derived from crosses between a sugarbeet line segregating for genetic male sterility and regional mixtures of *Beta maritima* or other subspecies of *B. vulgaris* are in the developmental stage. Except for the elimination of annuals, selection was not practiced in the first two cycles of random intercrossing. In the first two cycles, seed was harvested from male sterile plants to insure recombination of the two sources of germplasm (sugarbeet and wild types).

Following the two cycles of random intercrossing, two cycles of selection for early germination and fast leaf initiation have been conducted. Slow germination and slow leaf initiation have been observed by the author in many of these wild populations. Growth chamber selection procedures developed by this lab have proven effective in eliminating germination inhibitors and increasing leaf initiation. Both traits are highly heritable and can be selected against when conditions are properly controlled. The effects of one cycle of selection for early germination and early leaf growth are given in Tables 3 and 4, respectively.

Table 3. Mean emergence of the parent and first cycle populations. Data are for hours post-planting to emergence.

Population	Description*	Parent Population	1st Cycle Population
y221	Denmark	83	62
y223	Ireland	91	63
y222	Belgium	74	62
y219	*B. atriplicofolia*	74	62
y220	*B. patula*	79	69
y224	*B. macrocarpa*	78	67
z2	Turkey & India	70	67

* = Source of wild germplasm in the initial cross.

Table 4. Mean growth of first leaf at 135 hours post-emergence for parent and 1st cycle populations.

Population	Description*	Parent Population (mm)	1st Cycle Population (mm)
y220	*B. patula*	18.4	23.3
y222	Belgium	11.0	24.7
y223	Ireland	11.4	17.0
y224	*B. macrocarpa*	20.9	34.5
z2	Turkey & India	20.7	26.2

* = Source of wild germplasm in the initial cross.

In every cross there was a significant decrease in hours from planting to emergence for the first cycle of selection (Table 3). Hours from planting to emergence were very similar for each first cycle selection population, suggesting that most germination inhibitors had been eliminated in the first cycle.

There were significant differences in the growth rate of the first leaf of the parent populations (Table 4). The slowest were those with the North Atlantic as the source of wild germplasm. A significant increase in growth rate of the first leaf was observed after the first cycle of selection for all populations. These data suggest that the selection procedure was very effective. The parent and selection populations will be grown in the field in 1994.

Green Leaf Duration. Studies over the past three years (see Sugarbeet Research Reports 1991 and 1992) have found that: 1) the green leaf duration of the first leaf can be altered genetically, 2) selections for the green leaf duration of the first leaf affect the green leaf duration of other leaves as well as the leaf canopy in general, and 3) selection for early green leaf duration increased the frequency of annuals in populations segregating for annualism.

Subsequent studies have focused on strong biennial populations. Two cycles of mass selection for divergent green leaf duration have been completed in one broad genetic base population (i32) and one relatively narrow genetic base population (3747). These new populations along with their respective parent populations were evaluated in replicated field trials in 1993 (Tables 5 and 6).

TABLE 5. The effect of mass selection for leaf senescence (green leaf duration) on root yield, sucrose percentage and sugar yield.

Entry	Description	Root yield T/A	Sucrose %	Sugar yield LBS/A
y216 LL	2nd cycle - late	12.7a*	13.6a	3776b
x127 L	1st cycle - late	15.5a	13.5a	4202a
i32	Parent	13.3a	13.4a	3576b
x129 E	1st cycle - early	9.2b	13.0a	2392c
y218 EE	2nd cycle - early	10.0b	11.6b	2326c
LSD 0.05		2.9	1.0	628

* = Values followed by the same letter are not significantly different at $P = 0.05$.

TABLE 6. Effect of mass selection for leaf senescence (green leaf duration) on root yield, sucrose percentage and sugar yield.

Entry	Description	Root yield T/A	Sucrose %	Sugar yield LBS/A
y214 LL	2nd cycle - late	10.9a*	13.1a	2880ab
x125 L	1st cycle - late	13.3a	13.2a	3489a
3747	Parent	12.5a	13.2a	3303a
x126 E	1st cycle - early	11.5a	13.4a	3076ab
y215 EE	2nd cycle - early	11.5a	12.1b	2696b
LSD 0.05		2.9	1.0	628

* = Values followed by the same letter are not significantly different at $P = 0.05$.

Unfortunately, heavy rains in June and July flooded these yield trials, resulting in very low yields. However, the relative rank of other flooded trials did not change even though the root yields were reduced dramatically. Earlier pilot tests suggested that increasing green leaf duration increased root yield. The first cycle of selection substantiated these earlier data, especially in the i32 population (Table 5). Selection for increased green leaf duration (population x127 L) significantly outyielded the parent population for sugar yield and root yield. The divergent selection, i.e. for decreased green leaf duration (population x129 E), gave significantly lower sugar and root yields than the parent population. Divergent selection in the more genetically uniform population (3747) gave the same but not significant trends, i.e. increased green leaf duration increased yields and decreased green leaf duration decreased yields (Table 6).

The second cycle of divergent selection in each population did not have the same effect on yield (Tables 5 and 6). An additional cycle of selection for early green leaf duration, populations y218 EE and y215 EE, gave yields similar to the first cycle for early green leaf duration. The additional cycle of selection for increased green leaf duration, populations y216 LL and y214 LL, were lower in yield than the first cycle for increased green leaf duration.

The results of the second cycle of selection may reflect some apparent inbreeding depression in the second cycle. However, population numbers were between 30 and 50 selected roots and that number of roots in such a diverse population as i32 should not show significant inbreeding. It may also be suggested that the first selection cycle captured most of the additive genetic variation for this trait. Studies are underway to identify and evaluate the importance of non-additive gene action for this trait.

Leaf Initiation. Carefully controlled growth chamber selection techniques have shown that leaf initiation can be altered genetically. Preliminary evaluation tests in 1992 were inconclusive. This past year field trials were conducted to evaluate the effects of both mass selection and combining ability selection for leaf initiation on yield. These trials also experienced flooding which resulted in reduced yields.

Leaf initiation was measured at three-hour intervals. Those that initiated first (one SD above the mean) were intercrossed to produce the Fast Leaf Initiation population. Those that were the last to initiate leaves (one SD below the mean) were intercrossed to produce the Slow Leaf Initiation population. There was a significant difference in root and sugar yield between the fast and slow leaf initiation population (Table 7). The parent population was between the fast and slow leaf initiation populations but not always significantly different. Sucrose concentration was not affected by selection for leaf initiation.

TABLE 7. Effect of mass selection for leaf initiation on root yield sucrose percentage and sugar yield.

Entry	Root yield T/A	Sucrose %	Sugar yield Lbs/A
Fast Leaf Initiation	10.8a*	13.7a	2850a
Slow Leaf Initiation	8.1b	13.7a	2010b
Parent	9.6ab	13.6a	2501a
LSD 0.05	2.5	0.8	622

* = values followed by the same letter are not significantly different at $P = 0.05$.

Recurrent selection for leaf initiation combining ability was accomplished by test crossing each plant from a broad genetic base population to the L53cms inbred. As soon as crossing was complete, the male parent was trimmed and placed in a thermal induction chamber until the evaluation of all the test cross progeny was complete. Test cross progeny were evaluated for leaf initiation in controlled growth chambers. Male plants whose test cross progeny gave the fastest leaf initiation were intercrossed to produce a new Fast Leaf Initiation population, and those plants whose test cross progeny gave the slowest leaf initiation were intercrossed to produce a new Slow Leaf initiation population (Table 8). These new populations, their respective test crosses and the parent were tested in a replicated field trial in 1993.

Recurrent selection for fast leaf initiation resulted in significantly higher root and sugar yields as compared to recurrent selection for slow leaf initiation. The parent population yield was

TABLE 8. Effect of recurrent selection for leaf initiation on root yield, sucrose and sugar yield.

	Root yield		Sucrose		Sugar yield	
	Population	Test cross	Population	Test cross	Population	Test cross
	T/A	T/A	%	%	Lbs/A	Lbs/A
Fast Leaf Initiation	10.0	12.9*	13.1	13.7	2644	3540**
Slow Leaf Initiation	7.6	9.8	12.2	13.5*	1912	2550**
Parent	9.6		12.9		2501	
LSD 0.05	2.9		0.9		719	

* = Significant increase of test cross over population at $P = 0.05$.
** Significant increase of test cross over population at $P = 0.01$.

between the new fast and new slow leaf initiation populations but not significantly different from either (Table 8).

These results suggest that both additive and non-additive gene action are operative for leaf initiation and that both indirectly influence root yield. Since these data are from a field severely affected by flooding, additional studies are underway to gain more reliable data.

WORLD *BETA* NETWORK

D. L. Doney

BSDF Project 631

The Third International *Beta* Genetic Resources Workshop and World *Beta* Network Conference was held in Fargo, North Dakota, August 4-6, 1993. More than 70 scientists from 16 countries, including representatives from China, India, Japan, Poland, Egypt, Morocco, Eastern and Western Europe and the United States attended the three-day conference.

Founded in 1989, the World *Beta* Network (WBN) objective is to provide a forum for international involvement in *Beta* germplasm resources. In addition to germplasm activities such

as preservation, documentation, evaluation and utilization of germplasm, scientific sessions were held on Pre-breeding and Gene Transfer.

In the Pre-breeding session, talks covered theory, methods and the development and utilization of wild germplasm. Examples were given of the successful incorporation of foreign germplasm into useful cultivars. Other topics included pre-breeding for root architecture; male sterility; and root rot, nematode, virus yellows, and Rhizomania resistance. Two papers dealt with general aspects of pre-breeding in India and the former Soviet Union.

The Gene Transfer session concentrated on recent efforts to utilize new molecular technology to enhance sugarbeet pest protection and sugarbeet production. Topics encompassed the utilization of RFLP technology in *Beta* and the transfer of herbicide, nematode and root maggot resistance. One paper proposed a revision of the taxonomy of the genus *Beta*. This proposal, to be published in the next issue of the *Journal of Sugar Beet Research*, was considered and accepted by the conference.

A poster session of varied topics was also part of the conference. Contributions included tissue culture, isozyme characterization of wild germplasm, molecular identification of sugarbeet varieties, core collections, collecting beet in Egypt, and resistance to leaf spot, *Polymyxa*, BNYVV, and *Sclerotium* root rot.

The workshop section of the conference consisted of reports of germplasm activities from different parts of the world, proposals, and regional panel discussions and recommendations. Recommendations made by the conference were as follows:

1) Areas of naturally occurring *Beta* germplasm deficient in *ex situ* collection were identified. Priorities were centered in Middle Eastern countries with additional needs in several Mediterranean countries.

2) Recommended seed multiplication of selected germplasm for evaluation purposes. Several private companies, gene banks and government agencies agreed to participate in the seed increase program.

3) Evaluation for specific priority descriptors was identified as a major need. Several companies, gene banks and government agencies agreed to conduct evaluations based on their respective capabilities.

4) The proposed revision of the taxonomy of the genus *Beta* was discussed at length and officially accepted by the conference following an official release of the revision.

5) The proposal for a WBN newsletter was deemed unnecessary and shelved.

6) Past financing of the WBN has been obtained from the IBPGR and private industry. Future funding from both sources is unlikely. Recommendations were made to increase registration to cover conference costs and to petition international institutions to support travel of participants from developing countries.

7) The next WBN conference will be held in Izmir, Turkey (1995), to coincide, either before or after, with the summer meetings of the IIRB.

Other highlights of the conference included a field demonstration of the world *Beta* germplasm, a keynote speech by Henry Shands (Associate Deputy Administrator for Genetic Resources - USDA), and tours of the American Crystal Sugar Co. research facilities and Hilleshög AB research field trials.

Conference papers will be published in a special issue of the *Journal of Sugar Beet Research*.

BIOLOGICAL CONTROL OF SUGARBEET ROOT MAGGOT

C. A. Wozniak and Sarah E. Hinz

BSDF Project 641

Insect Endogenous Bacteria and Their Influence on Sugarbeet Root Maggot Development. Many multicellular organisms are closely associated with specific microbes and often fail to grow or develop normally in the absence of these symbionts. In most cases the role that these microbes play is unknown. We have demonstrated that the sugarbeet root maggot (SBRM), *Tetanops myopaeformis*, contains a set of bacterial associates that are reproducibly isolated from larvae originating in separate, distinct locations.

Our analyses of insect endogenous bacteria (IEB) associated with SBRM third instar larvae has led to the isolation and characterization of over 1000 bacteria from five states. Although some species are regularly found associated with SBRM (*i.e.*, *Serratia liquefaciens*, *S. marcescens*, *Flavobacterium indologenes*, *F. gleum*), they may be absent depending on geographic origin. We have found only one species, *Stenotrophomonas maltophilia* (formerly *Xanthomonas maltophilia*), to be ubiquitously encountered in SBRM larvae.

This finding implies some role for *S. maltophilia* (Sm) in the biology of SBRM. We have evaluated larvae reared in the absence of microbes (gnotobiotic) produced via surface disinfestation of SBRM eggs. Attempts to rear these gnotobiotic larvae in culture with sugarbeet suspension culture cells or seedling roots have proved unsuccessful. Growth and morphogenetic development (*e.g.*, moulting) failed to occur despite larval survival for time periods sufficient for development under field conditions.

Assessment of IEB in SBRM Development. To determine the potential of these IEB in SBRM development, gnotobiotic SBRM first instars were cultured with suspension culture cells on gelled medium with and without additions of individual bacterial isolates.

Surface disinfestation of laboratory-reared SBRM eggs was accomplished with detergents (*i.e.*, 1% (w/v) SDS, 0.03% (v/v) Roccal) and sodium hypochlorite (0.2% (v/v)). Lack of aerobic, heterotrophic organisms on nutrient media was confirmed. Gnotobiotic eggs placed on this

Murashige and Skoog Minimal Organics Medium (pH 5.7) with 3% (w/v) sucrose (MS0) hatched within 5 days at 24°C. Two days after egg placement, *Beta vulgaris* 'REL-1' suspension cultured cells (2.0 ml) were added to each 35-ml plate of MS0. Broth cultures of *Pseudomonas syringae 'aptata'* (from lesions on sugarbeet leaves), *Serratia liquefaciens* ATCC 27592, *Escherichia coli* 'JM109' and '2P16A' (from third instar SBRM) were quantified by absorbance measurements at 595 ηm and dilution plating. These bacterial cultures were added to MS0 plates in 100 μl broth containing 5 x 10^8 to 5 x 10^9 cfu. Control treatments included the absence of 'REL-1' cells, the absence of bacteria, or eggs-only with no added cells or bacteria. Attempts to rear eggs with total native IEB complement (*i.e.*, without surface disinfestation) resulted in overgrowth of MS0 plates by *Penicillium* or *Aspergillus*, thus precluding observations of SBRM growth and development.

Incubation of MS0 cultures at 24°C (16/8 h photoperiod in diffuse fluorescent lighting) resulted in establishment of the added bacteria in feeding tunnels of the larvae and on 'REL-1' cells. The low available organics and acidic pH minimized spread of bacteria across the medium surface, which prevented sugarbeet cells and larvae from being overgrown with bacteria which could have proved toxic due to production of waste products. Culture samples taken at the end of experiments (approximately 6 weeks) demonstrated the survival of strains added at the onset of egg hatch.

SBRM first instars incubated in the presence of *S. maltophilia* '2P16A' (or type strain ATCC 13637) moulted within 10 days. A concomitant increase in size and change in morphology (*e.g.*, sclerotization of caudal spiracles, development of secondary pharyngeal supports) also was observed. This development (moulting) was within the expected time frame for SBRM of 7 to 12 days based on field observations. Feeding of larvae was observed in all treatments with suspension culture cells regardless of bacterial addition. Utilization of sugarbeet cells and associated calli was observed by a decrease in tissue mass with time and a browning of calli; bacterial influence on tissue browning was not separable from effects of larval feeding.

Co-cultures of 'REL-1' cells and *Ps. syringae 'aptata'*, an opportunistic sugarbeet leaf pathogen, resulted in clumping of bacteria and sugarbeet cells into strand-like formations. However, this isolate was capable of providing for moulting and growth of SBRM larvae in the presence of 'REL-1' cells. No development was observed without cells in the presence of bacteria. Greenhouse evaluations of this organism demonstrated capacity for induction of a hypersensitive response (HR; browning, cell collapse) on tobacco and watersoaked lesions or chlorosis on *Beta vulgaris* B1745 and H5135. Hence, the response of suspension cells to *Ps. syringae* contact was not totally unexpected and may be a form of HR or disease etiology.

SBRM development proceeded in the presence of 'REL-1' cells and *E. coli* 'JM109'. It was apparent that these bacteria were influencing suspension culture cell multiplication and were proliferating at different rates than other bacteria on MS0 medium. Hence, direct comparisons are difficult, especially in these preliminary experiments.

S. liquefaciens ATCC 27592, although capable of inducing moulting in one instance, had an apparent negative influence on SBRM and 'REL-1' cells. This strain proliferated on MS0 and many deceased larvae were observed. The inherent variation in bacterial species and strains to

utilize different substrates as nutrient sources may in part explain the unusual growth of this organism on what would be considered a "minimal medium". In addition, sequestration of particular ions (*e.g.*, iron) by siderophores and antibiosis through secondary metabolite production are known to be responsible for competitive or allelopathic interactions.

The ability of various bacterial species to mediate the interaction between SBRM larvae and sugarbeet cells suggests a common factor(s) shared by many prokaryotes. Such commonality has been demonstrated in rearing of Muscidae (house flies) *in vitro*. Several unrelated gram negative bacteria were found capable of supplying gnotobiotic maggots with sufficient factor(s) to provide for larval development, however, their capacities to do so varied with individual species (Martin *et al.*, unpublished data). In contrast, many species of *Bacillus* (gram positive) were found to have inhibitory influence on house fly morphogenesis.

Due to the omnipresence of Sm on sugarbeet roots and within SBRM larvae, this species appears to be the most promising candidate for vectoring a toxic protein (*e.g.*, Bt-ICP, protease inhibitor) to the feeding court of this insect. Our evaluations on plant pathogenic potential of multiple Sm strains indicated that this species is not a plant pathogen. Experiments designed to assess the ability of culture filtrates of Sm to mediate the SBRM feeding interaction with sugarbeet tissue are underway. Fractionation of any active components could yield significant knowledge of the critical interplay of SBRM larvae and microbes. Engineering of Sm with foreign DNA at the chromosomal level could provide a specific, stable biopesticide applicable to sugarbeet hybrids via seed or soil inoculation. Our ongoing studies of microbial influence on SBRM will allow assessment of the sugarbeet rhizosphere with respect to scarring and for identification of a microbial vector for interruption of the SBRM life cycle.

Isolation and Characterization of *Bacillus thuringiensis* for Biocontrol of Sugarbeet Insect Pests. The naturally occurring soil bacterium *Bacillus thuringiensis* (Bt) is the most widely used biological pesticide worldwide and currently comprises approximately 2% of the total pesticide market. The ability to obtain isolates from numerous environmental sources without concern over patent or ownership rights has allowed significant commercial input in the development of new product formulations. Strains with biocidal activity towards many key insect orders and a few other invertebrate phyla have provided the target specificity and genetic variability needed to direct products towards specific markets.

Isolates with activity against Diptera (*e.g.*, blackflies, mosquitoes) are known. However, isolates with activity against the sugarbeet root maggot (SBRM; Diptera:Otitidae) or most other insect pests of sugarbeet have not been suitably evaluated. The two primary goals of this project were 1) to isolate, characterize and screen new Bt strains, and 2) to clone the responsible *cry* or *cyt* gene from Bt to a suitable rhizospheric bacterial vector (see Project 601 report).

Isolation of Bt. Established methods of Bt isolation were modified and combined to provide for isolation of Bt from a variety of samples. Soil, insects, plant debris and plant roots were sampled by suspending extracts in 0.85% saline and pelleting debris at low centrifugal force. The supernatants from these extractions were adjusted to 0.25 M with sodium acetate and incubated overnight at 30°C, 200 rpm. Under these conditions most microbes initiate growth and division with the exception of Bt endospores. Cultures were subsequently heat treated

(80°C, 10 min) and plated onto rich media with ampicillin (100 μg/ml) and Polymyxin B (40 μg/ml). After incubation for 24 to 48 h colonies resembling *Bacillus* spp. were subcultured to Bt/Amp/PolB for isolation. Isolates were gram stained, stained with Malachite green/Safranin O to check for crystal/spore production and biochemically characterized using the Biolog 3N database.

All environmental samples collected (soils from root zones, ant hills, horse barns, pastures and river banks) were positive for the presence of Bt. Forty-five isolates were obtained from these samples and were analyzed biochemically and genetically for differentiation into one of the five recognized Bt insecticidal crystal protein (ICP) subgroups. The combination of acetate selection, heat treatment and antibiotic selection during screening of samples yielded Bt strains with few extraneous organisms. *Bacillus* spp. identified were *B. thuringiensis* (Bt), characterized as: bacilliform, gram positive, spore forming aerobes, with crystal inclusion bodies. Although acrystalliferous strains of Bt are known to exist, we did not encounter any in our sampling. Several additional Bt strains were identified from our sugarbeet root and insect studies and similarly characterized.

Analysis of Bt Strains. Isolates were grown to sporulation (*i.e.*, cell lysis) in broth, centrifuged, washed in distilled water and separated on density gradients. Pre-centrifugation preparations of spores/ICP crystals and the fractions from the density gradients were analyzed by SDS-PAGE. Type strains of Bt (from ATCC, Rockville, MD) were also analyzed for comparison.

Protein profiles on SDS-PAGE from presumptive Bt isolates were indistinguishable from crystal preparations of 'israelensis' type strains treated similarly. Peptides in the 25 - 28 kD (*Cyt* A) range and 68 - 72 kD (Cry IV) range are predominant, with some isolates showing bands of 120 - 130 kD (presumably protoxin). Fractional analyses from NaBr density gradients, however, were hampered by irregular banding on the gradients. Diminution of density fractions in the ranges of presumptive Cry IV toxin proteins (on SDS-PAGE) suggested that some of these isolates were solubilized in NaBr during centrifugation. Solubilization of ICP during NaBr centrifugation has been attributed to Cry III toxins (*i.e.*, coleopteran active strains).

A *cry* IV-specific oligonucleotide primer was employed in a polymerase chain reaction (PCR) to evaluate the sequence and identity of ICP genes present in our isolates. Cry IV toxins have shown activity against numerous Dipteran insects and thus were chosen as the basis of our selection protocol. After screening over 70 isolates with *cry* I, *cry* III, and *cry* IV - specific primers via PCR, it was apparent that Cry IV ICP were the predominant proteins encoded in these strains. Several isolates, however, contained more than one reactive ICP sequence, as judged by PCR product size on electrophoretograms. This finding was corroborated in part by the complex plasmid profiles found in many of the strains, and by the ability of plasmid DNA preparations to serve as templates for PCR-mediated *cry* sequence production.

In vitro SBRM Feeding Assay. Latex spheres covalently bound with fluorescein (Fluospheres) were used to demonstrate uptake and ingestion by SBRM larvae of particulates within the known size ranges of Bt spores and ICP crystals. Larvae were observed to ingest and concentrate latex spheres in the size range of Bt spores and crystals, with primary concentration of these particles in the midgut region. The cibarial pharynx of larval SBRM is size selective with respect to

ingestion. Fluosphere uptake and retention in the midgut (evidenced by epifluorescence microscopy) indicated the potential of crystal/spore presentation to these insects during *in vitro* screening assays.

First instar SBRM were co-incubated with crystal/spore preparations from all novel isolates. Application of preparations to filter paper discs or in coarse sand resulted in none of the isolates being demonstrably toxic to the larvae. The lack of an *in vitro* rearing system for SBRM and the phytophagous nature of SBRM larvae preclude the addition of useful feeding adjuvants or stimulants to bioassays. The time provided for ingestion of spores and/or crystals may be insufficient in the absence of normal feeding behavior. Lack of available nutrition in assay mixtures may prevent sufficient uptake of ICP to ensure visible toxicity assessment prior to insect starvation. Investigations of lab rearing systems for culturing/bioassay techniques are underway. The finding by a colleague that one of our *cry* IV isolates has activity against a coleopteran pest of sunflower has influenced our decision to screen all isolates via bioassay and not to preclude any strains based on PCR data. The strict categorization of Cry toxin groups may not be as sound as once thought based on our findings.

NEMATODE RESEARCH

C. A. Wozniak, G. A. Smith and L. G. Campbell

The target specificity of entomopathogenic nematodes for soil-borne insects and their low environmental impact have made them a focus of our work on biological control of the sugarbeet root maggot (SBRM). This dipteran has been a cause of significant loss to sugarbeet growers in several states as larval root feeding reduces stand and severely debilitates surviving plants.

With the advent of large-scale production techniques, several species of entomopathogenic nematodes are now available for evaluation against insect pests. These insect-specific nematodes are known to infest and reproduce within a wide range of insects, but are especially useful and effective against soil-inhabiting larvae. Application and manufacturing methodologies have progressed to the point of economic feasibility for many cropping situations wherein a large, inundative release of infective juvenile (IJ) nematodes to the subsoil profile results in pest decline. The prolific reproduction of IJ within insect cadavers provides for secondary release within the target zone of the insect pest.

Two primary nematode groups, the steinernematids and the heterorhabditids, are the current focus with respect to agricultural use. Although the reproductive biology of these two groups differs somewhat, the basic mechanism of action is the same. Bacteria of the genera *Xenorhabdus* and *Photorhabdus* are symbiotic with nematodes in the Steinernematidae and Heterorhabditidae, respectively. Upon entry into the host insect via mouth, anus or spiracles, the gut-harbored symbionts are released to the haemocoel or blood sinus of the insect. Bacterial septicemia ensues within 24 h and death is usually apparent within 24 to 48 h. IJ nematodes utilize the degradation products of bacterial action as nutrition needed for reproduction. Several thousand new IJ are released from the host cadaver following exhaustion of nutrient supply.

Larval SBRM were assessed for their susceptibility to infestation/parasitism by IJ of three steinernematid species and one heterorhabditid species in laboratory bioassays. Co-incubation of any of the six strains of *Steinernema* spp. or the four strains of *Heterorhabditis bacteriophora* resulted in infection of third instar SBRM larvae. Application of commercially produced steinernematids or lab-reared heterorhabditids to coarse sand containing SBRM for 72 h always resulted in infection of at least some of the third instars. In several experiments, however, the initial presence of IJ observed within deceased larvae failed to result in nematode reproduction and release. The lack of suitable establishment of bacterial septicemia within the host is presumed to be the cause of reproductive failure. Our parallel studies on variation in SBRM endogenous flora indicated that antagonistic microflora could limit establishment of successful septicemic conditions by *Xenorhabdus* or *Photorhabdus* spp. Although death of SBRM ensued following nematode invasion, the proper nutrient composition was lacking for IJ reproduction.

Adult SBRM (flies) were also evaluated under lab conditions for susceptibility to steinernematid IJ. Flies were incubated on moist filter paper discs containing one of six strains of *Steinernema* spp. in numbers approximating field rates (*i.e.*, 3 X 10^9/A). Removal of flies at time points from 2 h to 36 h after introduction of IJ provided a time-course analysis of infectivity. Flies were transferred to sterile, coarse sand for observation of infection, death and IJ egress.

With as little as 2 h co-incubation, 42% of adult SBRM were observed to be infected, with death following in 12 to 24 h. Longer incubation times of 4, 6, 18, 21 and 36 h resulted in 50, 70, 75, 77 and 100% infection. Reproduction of IJ within flies was rapid relative to larval infections (3 to 5 days vs. 10 to 21 days) and presumably resulted from the rapid diminution of host nutrients in adults. Flies contain a predominance of sclerotized and chitinized structures not amenable to degradation and use as a nutrient source.

An unexpected observation resulted from *in vitro* evaluation of larval susceptibility. Third instar SBRM that had completed the mandatory diapause period (*i.e.*, cold induction) needed for pupation were often found to pupate in response to IJ exposure. This induction of puparium formation was presumed to be a defense response to nematode invasion. However, 25% of the resultant images were aberrant in morphology. The morphology of these aberrant flies included unretracted ptilina, misshapened head capsule, reduced sclerotization of the cuticle, reduced or absent wings, and a general diminutive nature. Attempts to obtain eggs from these aberrants was unsuccessful.

Field Assessment of SBRM Susceptibility. Six strains of *Steinernema* spp. were applied in subsoil along the length of sugarbeet rows for two consecutive seasons. Three applications of nematodes at 3 X 10^9 IJ/A were used to enhance the probability of influencing SBRM larval numbers. Infected third instars were collected from all nematode treatments, however, the heavy clay soil precluded accurate assessment of % infection. Sampling of larvae was skewed towards collection of healthy (white) larvae, as infected cadavers become soft, brown and are degraded within days in the soil.

Due to the excessive, abnormal rain patterns present over much of the Red River Valley these past two seasons, timely sampling of nematode persistence was hampered. However, we did find that IJs survived from the final application (late July) until the first week of October.

Additionally, many native nematodes with evidence of insect pathogenic potential were recovered from soil samples.

Comparison of strains, controls and chemical applications in 1993 indicated that one strain of *S. carpocapsae* (252) may have some potential against SBRM larvae. Overall, however, none of the other nematode strains indicated a statistically significant ($P = 0.05$) decrease in root damage ratings compared to controls. Similarly, with % sucrose, tonnage and sucrose purity, no statistically verifiable difference was noted with nematode treatments. We plan to assess heterorhabditid strains in 1994, along with novel strains of *Steinernema* previously unavailable. With more typical weather patterns for this area, we expect the experiments to reflect an accurate potential of entomopathogenic nematodes with respect to reducing SBRM numbers below critical damage levels.

Monitor stations and milk carton traps were evaluated in 1993 as infection sites for adult SBRM. Emerging flies from a previous season's beet field were captured in nonbaited monitor boxes and within milk carton traps baited with ammonium, eugenol or water. Milk carton traps contained *S. feltiae* '27' within a sand-polyacrylamide mixture and attractants (baits) were positioned alongside the trap. Sticky tapes (Pherocon-Am) attached to trap posts indicated a large, peak emergence on June 10, with erratic emergence patterns thereafter due to wind and rain patterns. Despite the abnormal emergence pattern, we were able to demonstrate that flies were infected by *S. feltiae* and that these nematodes survived at least 7 days within traps under field conditions. Eugenol was noted as having some potential as an attractant even though a statistical comparison of treatments was precluded by abnormal adult flight timing.

During the 1994 season, we plan to modify the trap and monitor designs, the assessment of various potential attractants, and the choice of nematode strains. The ability to decrease adult numbers prior to oviposition could significantly reduce resultant larval numbers on nearby seedlings.

SUGARBEET RESEARCH

1993 Report

Section E

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ABSTRACT OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION

SAUNDERS, J. W. 1993. Notice of release of smooth root germplasm with mutant form of ALS enzyme - EL-49

EL-49 is being released as a germplasm source for breeders to use in the development of smooth root breeding lines and cultivars. EL-49 is S_1 seed produced by selfing clone 10-181. Clone 10-181 was developed from a cross of clones 79B15x069 (the near cytoplasmic male sterile equivalent to EL-48) and CR1-AJ, followed by two successive outcrosses to two individual smooth root selections from smooth root line SP85700. Two resulting BC_1 individuals were then sibmated to produce the population out of which clone 10-181 was selected. EL-49 is a multigerm diploid with N cytoplasm, segregating for red and green hypocotyl. The parental clone 10-181 is highly self-fertile. EL-49 is expected to be used by breeders interested in the smooth-rooted characteristic. Less dirt clinging to beets during harvesting results in lower tare dirt percentage, a sanitation benefit in the face of the spread of the rhizomania disease across the U.S. There is also the potential for peel removal prior to processing as well as the likelihood of reduced post-harvest respiratory and rot losses. EL-49 is homozygous for a mutant form of the acetohydroxyacid synthase enzyme which can be used as a marker to confirm hybridization when EL-49 is used as a parent.

HART, S. E., J. W. SAUNDERS, AND D. PENNER. 1993. Herbicide resistant crops from cell selection. Reviews of Weed Science (Accepted 5/93, in Press).

Herbicide resistant cell lines have been selected using somatic cell selection in eleven crop species (tobacco, tomato, alfalfa, corn, white clover, flax, sugarbeet, carrot, canola, birdsfoot trefoil, petunia). Resistance has been obtained to herbicides of quite different modes of action, including ALS inhibition, lipid biosynthesis inhibition, as well as triazine, thiocarbamate, and growth regulator herbicides. Depending on individual cases, the resistances vary for availability in whole plants, for stability, for mode of inheritance, for origin by way of artificial mutagens, and for single or multi-step selective procedure.

HART, S. E., J. W. SAUNDERS, AND D. PENNER. 1993. Initial field evaluation of sulfonylurea herbicide resistant sugarbeet from somatic-cell selection. J. Sugar Beet Res. 31:(1+2)(Accepted 2/4/94)

Field studies were conducted with a sugarbeet (Beta vulgaris L.) breeding line segregating for monogenic dominant sulfonylurea herbicide resistance conditioned by the Sur_1 allele and obtained from somatic cell selection. Sulfonylurea herbicide resistant and susceptible sublines were compared to each other and to the commercially available susceptible cultivar MONO-HY E4 in regards to root yield, sucrose percentage, and processing purity. In addition, the response of MONO-HY E4 and the sulfonylurea resistant and susceptible counterparts to simulated carryover sulfonylurea residues in soil and to postemergence (POST) applications of selected sulfonylurea herbicides was evaluated. In the absence of herbicides, counterpart resistant and susceptible sugarbeet produced similar root yield,

sucrose percentage, and clear juice purity at both locations. Nicosulfuron applied preplant incorporated (PPI) at 9 g ai ha^{-1} to simulate carryover in soil had no effect on the growth of sugarbeets from the resistant population or from the susceptible MONO-HY E-4 cultivar seeded immediately after application. Primisulfuron and chlorimuron applied PPI at 10 and 3 g ai ha^{-1}, respectively, caused over 95% visible injury to the susceptible MONO-HY E-4 sugarbeet 6 weeks after treatment (WAT) but had no adverse effect on the growth of resistant sugarbeet. POST application of primisulfuron at 40 and 80 g ai ha^{-1}, and thifensulfuron at 4 and 8 g ha^{-1} (one and two times the normal field use rate for corn and soybean, respectively) caused less than 15% visible injury to the resistant sugarbeet 4 WAT, but caused severe injury to the susceptible MONO-HY E-4 sugarbeet. The sulfonylurea resistant sugarbeet was tolerant to POST applications of primisulfuron at four times and thifensulfuron at two times the field use rate. This magnitude of resistance is great enough for effective use of primisulfuron and thifensulfuron for weed control in sulfonylurea resistant sugarbeet.

THEURER, J. C. 1994. Agronomic comparison of different types of smooth root and "soil free" sugarbeets. J. Sugar Beet Res. 31:Accepted 12/3/93.

Field experiments were conducted for three years to compare growth characteristics and agronomic performance of sugarbeet genotypes differing in taproot architecture. Genotypes studied were MH E4 and either ACH 176 or ACH 185, commercial hybrids with standard grooved taproots; SR 87, a conical-shaped smooth root (SR) line developed by USDA, ARS at East Lansing, MI; A90MM, a globe-shaped SR experimental triploid hybrid from the Netherlands; and Univers, a European commercial variety with shallow root grooves and low soil tare at harvest. Taproot growth was primarily below the soil level for all genotypes except A90MM, which had only about 50% of the root underground. Averaged over years, root yield for SR 87 was 79.86 Mg ha^{-1}, significantly greater than the 70.72, 72.33, and 62.38 Mg ha^{-1} for A90MM, Univers and MH E4, respectively. Sucrose percentage for SR87 (15.31%) and A90MM (14.50%) was 1% - 2% lower than for U. S. commercial varieties. SR87 was equal to the commercial varieties in sucrose yield per hectare. There was little difference among all of the genotypes studied in clear juice purity. A90MM had about half the quantity of soil adhering to taproots as did SR87 and Univers and about one-fourth of that for standard grooved root varieties. A90MM produced 42 gm dry matter of top per plant compared to 75, 106, 108 and 121 gm for Univers, SR 87, MH E4, and ACH 185, respectively. Globe-shaped roots of A90MM were harvested with significantly less soil tare than conical-shaped SR beets. However, they had the disadvantage of often being dislodged from the row when tops were removed with a rotobeater. Using current sugarbeet harvesters the conical-shaped smooth root beets would be the more desirable architecture.

THEURER, J. C. 1993. Pre-Breeding for root architecture. J. Sugar Beet Res. 30:(4). (Accepted 12/30/93)

Economic improvement of sugarbeet (Beta vulgaris) field production and processing can be enhanced if traditional architecture of the sugarbeet is modified to a smooth root (SR) beet. Root shape of sugarbeet is a multigenic character and several generations of

breeding are needed to reach any degree of homozygosity. In recent years conical-shaped SR beets have been developed in the eastern U. S., and in the Netherlands globe-shaped beets have been developed by crossing table beet with sugarbeet followed by phenotypic recurrent selection. SR beets tend to have fewer fibrous rootlets near the soil surface than for traditional grooved-root beets but rootlets still proliferate mainly along two vertical planes. SR testcross progenies have shown less taproot tip breakage than for a commercial hybrid cultivar. Root yield of current SR genotypes and experimental hybrids has been equal or superior to that of commercial cultivars, but sucrose content has been 1-3 percentage points less. Soil tare for SR genotypes has ranged from 30% to 70% less than for current commercial cultivars with traditional architecture. Globe-shaped beets have lower soil tare than conical-shaped SR beets. However, SR beets bred with conical-shaped are more desirable than globe-shaped roots using current sugarbeet harvesting equipment, because globe-shaped beets grow more out of the soil, often are dislodged from the row when tops are flailed, and may not be picked up by the harvester.

SOMATIC CELL SELECTION STUDIES

Somatic Cell Selection for Resistance to Methionine Sulfoximine and to Ethionine

Joseph W. Saunders and Philipp Kapranov

One goal was to select for in vitro occurring variants having increased levels of glutamine synthetase. Selection for resistance to a specific inhibitor of glutamine synthetase (GS), L-methionine sulfoximine (MSO), was chosen on the basis of reported isolation of GS overproducing cell lines in a number of plant species following step-wise (chronic) selection for tolerance to MSO or another GS inhibitor, phosphinothricin. We employed direct selection, which has been successful in producing cell lines overproducing GS or other inhibitor-targeted enzymes due to gene amplification in animal systems, and in producing an uncharacterized MSO resistance in tobacco (Carlson, 1973).

Sieved suspension cultures of REL-1 were plated on media containing 2-5 times the LD_{100} concentration of MSO. A total of 1.5 X 10^8 cell clusters (7600 dishes) were plated. No true resistant isolates have been obtained. We then tried chronic (stepwise) selection. The first round of selection resulted in adaptation of cultures (the criterion was normal growth) to the LD_{50} concentration, followed by a doubling of the concentration of MSO with each succeeding round of chronic selection. We ultimately obtained cultures capable of normal growth at as high as 12.5 times the LD_{100} (the lowest lethal) concentration. However these cultures had completely lost their ability to regenerate shoots after their 6 months in culture. Shoots could be regenerated from cultures adapted only as far as 0.8 times the LD_{100} (3rd round of chronic selection). Now we are propagating those shoots, which look normal, for further trials. We have not been able to regenerate shoots from cultures adapted to higher levels of MSO, despite extensive efforts: a total of 3000 dishes plated with cultures adapted to various levels of MSO.

Selection for resistance to ethionine, an analog of methionine, is the other part of the current selection efforts. Methionine was demonstrated by Winner (1966) to protect beets in hydroponic culture from Aphanomyces attack. As some ethionine resistant mutants in other species have elevated methionine levels, we hope to test whether variant cells selected for ethionine resistance have elevated methionine levels in the whole plant and whether this is associated with greater tolerance of the Aphanomyces pathogen.

Nearly 1 X 10^6 cell clusters have been plated so far, most with an acute exposure to lethal levels of the ethionine. One resistant callus line has resulted, and we are attempting to get this to regenerate shoots now.

Alternate Nitrogen Sources for Callus Induction from Leaf Discs and for Subsequent Bud Regeneration

Joseph W. Saunders and Chia-Jung Tsai

Nitrogen is an important element for stimulating early seedling growth and rapid development of the sugarbeet canopy. However, an excess of nitrogen near the end of the growing season results in lower sucrose percentage in the taproot, and higher levels of impurities that interfere with sugar crystallization in the processing factory. Furthermore, nitrate levels in groundwater have become a matter of public concern and could probably be decreased by avoiding excessive nitrogen application relative to efficient crop needs.

Nitrogen is taken up by the beet crop primarily in the form of nitrate. Nitrate passes though the root unaltered, and is reduced in photosynthetic tissues, ending up as glutamine (Burba, 1983). Roots rely for their organic nitrogen on the downshipment of organic foliar nitrogen, primarily glutamine. From a beet root processing point of view, glutamine/glutamate is major component of clear juice impurity. It is also the key hub of active organic nitrogen distribution in the cell. Glutamine/glutamate concentration in the roots is probably regulated by multiple mechanisms.

Mutations of either regulation or enzyme function for the steps of nitrogen uptake, transport, reduction and interconversion could be of interest to the beet industry if these mutations were associated with (a) greater fertilizer use efficiency, (b) greater sugar percentage and juice purity (in the case of poorer efficiency), or (c) simply lower nitrogenous clear juice impurity levels (if glutamine/glutamate pool levels in the root are lower).

There are few plant mutations know to affect nitrogen assimilation without drastic effects on plant vigor. One example involves the two gene system differentiating burley and flue-cured tobacco that confers a four-fold difference in nitrogen use efficiency, and is expressed primarily in the shoot (Crafts-Brandner et al., 1987). This genetic variation occurred naturally.

Tissue culture provides a way to generate variants in nitrogen metabolism, either by spontaneous somaclonal variation or by use of a mutagen. For example, Heimer and Filner (1970) selected a tobacco cell line that was resistant to threonine inhibition of growth on nitrate as sole nitrogen (N) source. In sugarbeet, Sabir et al., (1992) identified a glutamate dehydrogenase overproducer in a random growout of regenerant plants. In neither case was seed available for field testing.

We have developed a system for plating out sugarbeet cells of an amenable genotype (REL-1) for selection of variants and regeneration of plants from these cells (Saunders et al., 1990). This system was effective in recovery of a sulfonylurea herbicide resistance factor (Saunders el al., 1992) and in subsequent recovery of additional herbicide resistance factors when the system was employed by weed scientists (unpublished). We have recently been developing selective regimes to efficiently select for variants of nitrogen assimilation that might enhance agronomic performance with respect to N use efficiency or processing purity.

Three types of selective regimes were identified earlier: (1) selection for growth in the presence of inhibitors of nitrogen assimilation steps when the traditional tissue culture N mix of nitrate and ammonium is provided to the cells, (2) selection for growth in the presence of a sole nitrogen source and an inhibitor of the utilization of that source (the vulnerability scheme), (3) selection for ability to utilize an otherwise unusable sole carbon or nitrogen source.

All three of these types of positive selection can be considered qualitative methods,

because they identify the rare surviving individual colony in an acute (one time) exposure to the selective environment. However, another type of positive selection relies on the fact that in a growing cell population, the arising of new genetic variation providing advantages to utilizing the ambient nutrients will lead to a disproportionate (quantitative) increase in the frequency of those variant cells. This disproportionate increase should also be reflected in the population of regenerate plants. In practice, to identify some of these variants will require a grow out of regenerate plants and some kind of progeny test. Because this type of selection targets no specific enzyme, involves changes in cell population gene frequency, and relies on the progeny test to identify variants in field performance, it's efficiency is low. It's advantage would be that the initial stage of performance identification would be very close to that of final application, i.e., the field as contrasted to the petri dish.

To this end we tested various sole nitrogen sources for their ability to support induction of callus from leaf discs and subsequent regeneration of buds or shoots from that callus without transfer. This is the first step we use in our standard system for generating callus derived plants for a grow out.

The experiment was run twice, once with leaves from REL-1 plants grown in a growth chamber and the second time from REL-1 plants grown in the greenhouse in November, without supplemental light. There were some differences in the outcome which might reflect differences in leaf physiological condition at the time of sampling, for example, due to light quantity per day.

The Murashige-Skoog N mix gave the best callusing and bud regeneration response, followed next by glutamine at 15 mM (Table 1). Buds were also produced on ammonium, urea and choline to a lesser extent. Paralleling the earlier lack of response in suspension plateout (SP) and shoot culture (SC) growth, betaine and proline supported no callus induction. Glutamate was also incapable of supporting leaf disc callus induction, similar to its response for SC but contrasting to its moderate SP growth. Most surprising was the poor support offered by nitrate, which earlier had given moderate growth of SP and SC. One explanation of this would be that the typical partially expanded leaves used as sources of discs have not developed very high nitrate reductase activity levels because they are still in a net assimilate importation stage on the plant.

It is apparent though that by using glutamine as a sole N source, callus induction and bud regeneration can occur at high enough levels to permit efficient recovery of plants. If there has been quantitative selection for cell variants better able to grow and utilize glutamine, this could lead to enhanced recovery of respective plants in a growout and progeny test.

Table 1. Number of leaf discs (of ten) which callused and which regenerated buds.

	MS_N✷	MS-N	NO_3^- 30✦	NO_3^- 60	NO_3^- 90	NH_4^+ 30	NH_4^+ 60	urea 15	urea 30	urea 60
Expt A	10,10¤	0,0	6,2	2,1	0,0	10,0	7,0	9,1	8,0	10,0
Expt B	10,8	0,0	0,0	0,0	0,0	7,5	3,1	6,1	8,1	6,0
Total▲	20,18	0,0	6,2	2,1	0,0	17,5	10,1	15,2	16,1	16,1

	gln 15	gln 30	gln 60	glu 30	glu 60	pro 30	pro 60	bet 30	bet 60	cho 30	cho 60
Expt A	10,8	8,5	7,1	0,0	0,0	9,1	4,1	0,0	0,0	0,0	0,0
Expt B	10,2	7,7	2,0	0,0	0,0	3,0	4,0	0,0	0,0	0,0	0,0
Total	20,10	15,12	9,1	0,0	0,0	12,1	8,1	0,0	0,0	0,0	0,0

✷ MS_N = Murashige-Skoog N mix of nitrate and ammonium; Murashige-Skoog inorganics without N; NO_3^- = nitrate; NH_4^+ = ammonium plus succinate; urea; gln= glutamine; glu= glutamate; pro= proline; bet= glycine betaine; cho= choline.

✦ Numbers = mM.

¤ First number of the pair is number of discs callusing (of ten), and second is number of discs producing buds from the callus.

▲ Of twenty leaf discs.

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1993 EXPERIMENTS OF GENOTYPE X NITROGEN RESPONSE

J. C. Theurer and J. W. Saunders

EVALUATION OF DIVERSE GENOTYPES FOR POTENTIAL NITROGEN USE EFFICIENCY.

Nitrogen fertilization is an important aspect for growing a good sugarbeet crop. Sufficient N is required for the beet to make rapid growth in the spring and to quickly develop a canopy of leaves for photosynthesis, further plant growth, and sucrose accumulation. Excess N at harvest results in higher impurities in the root and more difficulty in processing to sugar. Also, in recent years the public has expressed considerable concern regarding the quantity of nitrogenous and other chemical residuals in soils and water. In 1990 a research program was initiated to evaluate diverse genotypes for their potential difference in tolerance to high N or their efficiency for high sugar production with low nitrogen availability. Minor differences in N response were noted for some genotypes in past years. In 1993 we continued this research by evaluating some additional diverse genotypes for their response to differential nitrogen fertilization.

Sixteen highly diverse genotypes (Table 1) of sugarbeet including one selection with Beta macrocarpa parentage and two with B. maritima parentage were planted in a randomized block experiment of four replications at the Bean and Beet Research Farm on May 14, 1993. Individual plots were two rows 28" apart and 30' in length. Adequate phosphorus and potassium fertilizer was applied pre-plant but no N fertilizer was applied until after thinning. In mid-July the plots were fertilized with zero, 90# ammonium nitrate/acre (optimum nitrogen fertilization for Michigan), or 180# ammonium nitrate/acre in accordance with the randomized block field plan. The experiment was machine harvested on October 7, 1993. The row length of each plot was measured just prior to harvest to adjust plot size for any skips within the rows. All roots in each plot were weighed to determine root yield and RWSA. A fifteen beet random sample of roots was taken from each plot to determine sucrose percentage, CJP percentage and meq amino N per 100 g sugar. These determinations were made by Michigan Sugar Company personnel at their research lab in Carrollton, MI. Data was summarized and analyzed using the MSTAT statistical program developed at Michigan State University.

RESULTS

Summed over genotypes, when N was increased, root weight, recoverable sugar per acre (RWSA) and meq amino N/100g. sugar in the root at harvest were increased, while sugar content, recoverable sugar per ton (RWST) and clear juice purity (CJP) were decreased (Table 2). Significant differences were also noted between the genotypes (Table 3). The nitrogen level x genotype interactions were significantly different for all variables except for recoverable sugar per acre (RWSA) (Table 4). All genotypes showed an increase in RWSA with an increase in N fertilization, but yield differences were not significant for any of them. Four genotypes (90318, Ovana, A93-2, A93-5) had significantly higher RWST at the zero N level than at higher N levels. The other twelve genotypes, had significantly lower RWST at the 180# N rate than at the zero rate and six of these genotypes (ACH185, 88S3-00, 85320-0, 85576-0, A93-3, USH20) also were significantly lower in RWST at the 180# level than at the 90# N level. Ten entries produced significantly higher root yield at 180# N, than at the zero N level. For two of these genotypes

(88S3-00, A93-10), the 180# level also showed significant yield increase over the 90# N level. Root yield increased with increased fertilizer for the other six genotypes, but differences were not significant. Two genotypes (A93-2, A93-5) had significantly higher sucrose content with zero fertilization than with either 90# or 180#/ acre fertilizer level. Ovana, the genotype with the lowest sucrose content, was the only genotype that had similar sucrose percentages at all N levels. The majority of the genotypes had significantly lower sucrose content when grown in the 180# N environment. Seven of the genotypes (91270M,88S3-00,85320-0,85576-0,A93-3,A93-10,USH20)were significantly lower in sucrose percentage at the 180# rate compared to when they were grown with the standard 90#/acre N. Entries 88S3-00, 90318, 85576-0, A93-2, and A93-5 showed significantly higher purity with zero versus higher levels of fertilization. The 180# fertilization rate resulted in significant increases in the meq amino N/ gram sucrose in the beet root at harvest for the majority of the genotypes. The commercial cultivars ACH 185 and Beta 5315 showed little difference in amino N across fertilizer levels, while most genotypes showed an increase in amino N as the level of fertilizer increased. Only genotype A93-5, a progeny from L53 x B. maritima, showed significant step wise increases in amino N from zero to 90# and 90# to 180#.

Genotypes that have the best prospects for producing good yields, and high sucrose content under a low N environment appear to be 91270M, a selection from L19, and 91B21, an East Lansing selection for high RWST. None of the genotypes showed good prospect for finding germplasm that could utilize abundant nitrogen and still produce good sugar content with acceptable quantities of nitrogenous impurities in the root. Ovana and A93-2 genotypes showed the least sensitivity to loss of sucrose when N level is increased from 90#/acre to 180#/acre. Ovana, however, has very low sugar content to begin with, and partitioning to root growth versus sucrose accumulation may have an effect of keeping the sucrose content fairly stable in this fodder beet. Three genotypes (88S3-00, USH 20, and 85576-0) showed more sensitivity than others when the N level was raised from 90# to 180#/acre, resulting in reductions in sugar content of 2.6, 1.7 and 1.5 percentage points respectively. Two genotypes (L19 Select, and A93-3) had good sugar yield (RWSA) and high sugar content at the zero N level. ACH 185, Beta 5315, and 88S3-00 also had high sucrose percentage under the zero N treatment.

SELECTION FOR HIGH SUCROSE PERCENTAGE, HIGH AMINO N AND LOW AMINO N IN THE L19 HIGH SUCROSE GENOTYPE.

Past years experiments have demonstrated that the L19 genotype, which has very high sucrose percentage, also has a high accumulation of amino N in the roots at harvest. High sucrose , high amino N, and low amino N selections were made from two field block plantings of L19 in 1990. One field block had zero nitrogen applied during the growing season; and the other block was fertilized with 180# available N per acre, about twice the recommended rate for sugarbeets grown in Michigan. In 1992 five progenies selected from the high sugar line L19 grown in low and high N field plots were evaluated in the field along with the L19 parent line. The study was done to assay the effect of N fertilizer on the relationship of sucrose percentage and amino N impurities in the beet root at harvest in this high sucrose germplasm. In 1993 we repeated the experiment. Three of the selections tested were from seed increases of beets selected for high sucrose, high amino N, and low amino N when grown in a low nitrogen environment. The two other progenies were high sucrose and high amino N selections from beets grown under high N (180#/acre) fertilization. Insufficient seed was available for field planting of low amino N selection grown in a high N environment. The 1993 field trial was fertilized at the rate of 90# available N/acre, the recommended rate for sugarbeets grown in Michigan. Individual plot size for each entry was two rows 28″ apart and 30′ in length. Sufficient residual seed was available to plant only three replications. The experiment was machine harvested October 7, 1993. All beets in a plot were weighed for root yield and a random 15 beet sample was selected to determine sucrose percentage, purity and meq amino N/100 grams of sugar. The latter determinations were made by Michigan Sugar Company personnel in their laboratory at Carrollton, MI.

RESULTS

The data from the 1993 planting was similar to that collected in 1992 (see Table 7 p.E25 1992 Research Report). The L19 parent line again had the largest root yield and recoverable sugar per acre (RWSA) (Table 6). The high sucrose selection made under low N (92S19-01) had the lowest root weight both years, and was lowest in RWSA in 1993. The high amino N selection from the high N field plot, 92N19-04, was equal to the L19 parent in 1992 in RWSA, but it had significantly lower sugar yield than L19 in 1993. The high sucrose selection 92S19-01, as expected, had the highest sucrose percentage and recoverable sucrose per ton (RWST) for both years. There were no differences in clear juice purity percentages between all entries in 1992, However, the L19 parent and the low amino N selection 92N19-01 had significantly higher CJP percentage in 1993 than 92N19-04 and 92SN19-01, the high Amino N selections. The high Amino N selection made in the low N field (92SN19-01) was consistent over years in having the highest meq amino N/100 g. sugar. The low amino selection, 2N19-01, had the lowest amino N values both years. The data shows that selection for amino N can be very effective. It also demonstrates a close association with CJP percentage and the meq amino N/per 100 g. sugar in the root at harvest. The data also suggest independence of the genetic factors governing sucrose accumulation and amino N impurity level. They demonstrate that the characteristically high amino N found in the root of L19 at harvest can be greatly modified by selection for low amino low N retention in the mature sugarbeet root.

Table 1. Description of genotypes used in Nitrogen efficiency study.

	Genotype	Description
1	ACH 185	Commercial hybrid
2	BETA 5315	Commercial hybrid
3	91270M	L19 Sel. High sucrose
4	90729	SR line
5	88S3-00	H.S. Composite
6	85320-0	Coe Beta maritima line
7	91B21	88B24-01
8	90318	FC701/5
9	Ovana	Blanca
10	85576-0	Coe O-type inbred
11	A93-2	4 cyl C3747 X B. macrocarpa
12	A93-3	4 cyl L53 X B. maritima
13	A93-5	4 cyl L53 B. maritima
14	A93-10	h 537 hi soluble solids.
15	A93-8	h 535 round beet selection
16	USH20	Old Leafspot Resistant hybrid

Table 2. Means for N level summed across varieties for sugar yield, root yield, sucrose percentage, clear juice purity percentage, and meq amino N/100 g. sugar. B&B Farm. 1993.

N Level # Acre	RWSA	RWST	T/A	Suc %	CJP %	Amino N meq/100 g suc.
0	3590	227.7	16.08	16.55	91.94	22.47
90	3829	211.9	18.43	15.92	90.66	17.46
180	4006	192.2	21.08	14.78	90.00	12.09
Mean	3808	210.6	18.53	15.75	90.87	17.34
LSD(0.05)	465	6.2	2.1	0.34	0.58	0.53

Table 3. Means for varieties summed across N Levels for sugar yield, root yield, sucrose percentage, clear juice purity percentage, and meq amino N/100 g sugar. B&B Farm. 1993.

Variety	RWSA	RWST	T/A	Suc %	CJP %	Amino N meq/100 g suc.
ACH185	4686	251.0	18.81	18.00	92.31	9.87
BETA 5315	4379	250.1	17.62	17.89	92.45	9.66
91270M	4453	256.0	17.48	18.64	91.61	12.82
90729	4457	197.8	22.78	14.81	91.18	14.70
88S3-00	3805	231.9	16.57	17.11	91.36	13.78
85320-0	2851	192.8	14.95	14.84	90.06	21.72
91B21	4844	224.0	21.74	16.48	91.54	12.97
90318	3061	192.3	16.20	15.11	89.20	22.03
Ovana	3559	138.7	25.84	11.64	87.68	26.29
85576-0	3280	213.7	15.75	15.77	91.50	14.74
A93-2	3032	213.9	14.25	15.87	91.26	19.91
A93-3	3579	234.6	15.32	16.94	92.20	13.23
A93-5	2665	204.1	13.40	15.43	90.60	25.48
A93-10	4383	192.1	23.11	14.76	90.15	18.69
A93-8	3329	149.6	22.43	12.30	88.34	28.47
USH20	4573	227.6	20.19	16.41	92.39	13.06
Mean	3808	210.6	18.53	15.75	90.87	17.34
LSD(0.05)	465	6.2	2.1	0.34	0.58	0.53

Table 4. Sugar yield, root yield, sucrose percentage, clear juice purity percentage, and meq amino N/100 g. sugar for diverse sugarbeet genotypes grown under three N environments. B&B Farm. 1993.

Variety	RWSA #	RWST #	Tons/ acre	Suc %	CJP %	Amino N meq./100g	Level N #/A
ACH185	4492	268.6	16.72	18.93	92.94	7.43	0
	4569	253.9	17.97	18.11	92.55	8.93	90
	4997	230.4	21.73	16.96	91.43	13.25	180
BETA 5315	4066	266.9	15.27	18.75	93.12	6.44	0
	4467	251.5	17.76	18.01	92.42	9.48	90
	4603	231.9	19.83	16.92	91.80	13.08	180
91270M	4395	271.3	16.26	19.43	92.19	8.23	0
	4332	257.7	16.81	18.89	91.30	13.72	90
	4632	239.1	19.36	17.60	91.34	16.49	180
90729	4125	212.6	19.58	15.59	91.88	9.17	0
	4653	196.8	23.68	14.82	90.98	17.47	90
	4594	183.9	25.06	14.02	90.67	17.44	180

Table 4. continued

Variety	RWSA #	RWST #	Tons/ acre	Suc %	CJP %	Amino N meq./100g	Level N#/A
88S3-00	3603	245.2	14.63	17.58	92.57	10.54	0
	3668	245.6	14.95	18.19	90.99	12.80	90
	4142	205.0	20.13	15.55	90.51	18.00	180
85320-0	2304	203.1	11.43	15.46	90.39	16.80	0
	3188	200.8	15.92	15.19	90.71	21.39	90
	3061	174.4	17.51	13.87	89.09	26.98	180
91B21	4661	240.3	19.41	17.29	92.33	7.62	0
	4966	225.0	22.06	16.53	91.62	12.55	90
	4905	206.6	23.75	15.61	90.67	18.74	180
90318	2918	215.9	13.59	16.07	91.17	14.32	0
	3016	190.0	16.02	15.11	88.83	20.13	90
	3248	170.9	19.01	14.16	87.60	31.62	180
Ovana	3464	149.2	23.21	12.07	88.96	21.77	0
	3316	126.9	26.19	11.35	85.88	29.48	90
	3896	139.9	28.13	11.50	88.20	27.61	180
85576-0	3268	232.9	14.35	16.60	92.87	10.09	0
	3355	218.9	15.52	16.09	91.66	12.46	90
	3219	189.3	17.37	14.63	89.97	21.68	180
A93-2	2740	239.0	11.35	17.00	92.88	14.64	0
	2986	206.6	14.46	15.54	90.86	19.26	90
	3368	196.2	16.94	15.08	90.03	25.84	180
A93-3	3489	249.3	13.96	17.77	92.66	10.58	0
	3465	239.7	14.42	17.20	92.46	11.86	90
	3785	214.6	17.59	15.86	91.49	17.26	180
A93-5	2600	245.2	10.77	17.02	94.13	12.17	0
	2760	192.6	14.32	15.20	89.08	28.72	90
	2635	174.6	15.12	14.05	88.63	35.55	180
A93-10	4170	208.5	20.21	15.59	91.07	12.70	0
	4195	194.5	21.55	14.95	90.13	18.98	90
	4783	173.3	27.57	13.74	89.25	24.40	180
A93-8	2961	159.2	18.79	12.87	88.76	21.11	0
	3484	151.8	22.93	12.43	88.45	30.63	90
	3541	138.0	25.55	11.59	87.82	33.68	180
USH20	4181	236.7	17.68	16.78	93.06	9.77	0
	4844	238.4	20.31	17.05	92.63	11.55	90
	4693	207.8	22.58	15.40	91.47	17.87	180
Mean	3808	210.6	18.53	15.75	90.87	17.34	
lsd(0.05)	465	6.2	2.1	0.34	0.58	0.53	

Table 5. Agronomic evaluation of high sucrose, high amino N, and low amino N selections of L19 grown in high and low nitrogen environments. B&B Farm 1993.

Selection Seed No.	Selection Basis	RWSA lbs	RWST lbs	Root Wt. Tons/ac
	Low Nitrogen Field Plot			
92S19-01	High Sucrose	4627 b*	288.8 a	16.03 b
92SN19-01	High Amino N	4943 ab	279.5 ab	17.68 ab
92N19-01	Low Amino N	4671 ab	270.5 b	17.28 b
	High Nitrogen Field Plot			
92S19-02	High Sucrose	4999 ab	279.1 ab	17.91ab
92N19-04	High Amino N	4509 b	265.3 b	17.00 b
WC9127OM	L19 High Sucrose Parent Line			
Mean		4838	275.8	17.56
lsd (0.05)		595	15.2	2.02
CV		6.75	3.02	6.33

Selection Seed No.	Selection Basis	Sucrose %	CJP %	Amino N meq/100g
	Low Nitrogen Field Plot			
92S19-01	High Sucrose	20.76 a	91.84 ab	12.78 ab
92SN19-01	High Amino N	20.43 a	91.20 b	14.97 a
92N19-01	Low Amino N	19.40 c	92.13 a	10.55 b
	High Nitrogen Field Plot			
92S19-02	High Sucrose	20.26 ab	91.50 ab	14.61 a
92N19-04	High Amino N	19.51 bc	91.08 b	12.02 ab
WC9127OM	L19 Parent Line	19.47 c	92.15 a	12.02 ab
Mean		19.97	91.65	13.09
lsd (0.05)		0.75	0.84	3.60
CV		2.07	0.50	15.14

* Duncan's Multiple Range Test - Means with the same letter suffix are not significantly different at the 0.05 level.

EVALUATION OF SUGARBEET SMOOTH ROOT BREEDING LINES AND EXPERIMENTAL HYBRIDS - 1993

J. C. Theurer

Excellent smooth root architectured beets have been developed, but they do not have the level of sucrose percentage nor the disease resistance that is desired for today's commercial varieties. In 1993 we continued our efforts to enhance these characteristics in SR germplasm. Selections, experimental hybrids, and SR populations were evaluated for their agronomic performance. A SR nursery with over 3000 plants was screened, and selections having excellent smoothness of root and sucrose percentage above that of the check cultivar ACH 185 were again made for seed increase for the next selection cycle. Some excellent resistance to Cercospora leafspot was also noted this year.

EVALUATION OF A GROUP OF HIGH SUCROSE SMOOTH ROOT GENOTYPES.

This experiment was designed to evaluate the agronomic performance of a group of high sucrose smooth root (SR) progenies. Individual beets with good SR shape and sucrose percentage on a fresh weight basis ranging from 100-117% of that for ACH 185 were selected from the 1991 SR breeding nursery. Seed was produced in groups with 3-10 roots in each group, depending upon the pedigree of the breeding material. The eleven SR progenies plus ACH 185 commerial hybrid check were planted in two row plots with rows 28" apart in a 6 replicate field trial. Just prior to harvest the length of each plot row was measured and adjustments made to correct the plot area for skips that occurred within the row. Harvest by machine was done on October 7, 1993. All beets in each plot were weighed to determine the tons per acre, and recoverable sugar per acre (RWSA). A fifteen beet random sample of roots was taken from each plot for sugar and purity analyses. Sugar percentage and clear juice purity were determined by Michigan Sugar Company personnel in their research laboratory at Carrollton, MI using standard thin juice methods. A root smoothness score was estimated for each plot by observing the beets as they fell into the weighing basket. Beets were scored on a 1-5 scale as defined below:

1 = Very smooth taproot, no grooves, broad fibrous root zone
2 = Smooth, slightly grooved taproot, narrow fibrous root zone
3 = Partially smooth, grooved, heavy fibrous non-branching taproot
4 = Rough shaped taproot, deep grooves, heavy fibrous roots with some sprangling
5 = Very rough, very deep grooves, multiple branched taproot

Data was analyzed using the Michigan State University MSTAT statistical program.

RESULTS

With the exception of one SR progeny, the SR lines were not different from ACH 185 in recoverable sugar per acre (RWST)(Table 1). Five SR progenies slightly exceeded the check cultivar in root weight, however none of the 11 yielded significantly more or less than the check. ACH 185 had significantly the highest recoverable sugar per ton (RWST) and the highest sucrose percentage. Progenies 92HS10, 92HS33, and 92HS46 were the SR progenies with the highest sucrose content. These progenies were developed from groups of selected individual roots, which averaged 112%, 113%, and 110% of the sucrose of ACH 185 on a fresh weight basis. All but two SR progenies were equal to the check in clear juice purity (CJP). Only nine of the SR lines were significantly lower in smooth root score than ACH 185. Progeny 92HS45 had the best SR architecture. The best progenies for continued selection based upon the desirable characteristics of good sugar yield, high sucrose content and SR architecture, appear to be 92HS10, 92HS30, 92HS32 and 92HS33.

EVALUATION OF GENOTYPES DERIVED FROM INDIVIDUAL BEET SELECTIONS MADE IN THE 1992 SMOOTH ROOT BREEDING NURSERY.

This experiment was an agronomic evaluation of high sucrose SR progenies derived from individual beet selections made in the 1992 SR breeding nursery. Selections were made on the basis of good SR type and sucrose content which was equal or better than that of ACH 185. Seedlots were produced in the 1992-93 winter greenhouse and planted in field trials at the Bean and Beet Research Farm near Saginaw, MI on May 21, 1993. Seed numbers and a descriptive background of the plant material are listed in Table 2. The experiment consisted of; 20 SR progenies and two commercial cultivars, ACH 185 and MH E4. The entries were seeded in two row plots with rows 28" apart in a random block design of 6 replications. The field trial was harvested October 5, 1993 and other data collected in the same manner as cited above.

RESULTS

Fourteen of the SR entries were equal to ACH 185 in RWSA and six SR entries were inferior in sugar yield (Table 2). Four entries had root weigh significantly higher than the ACH 185 commercial cultivar and two were inferior in tonnage. One SR progeny, 93HS30, was significantly better in RWST and sucrose percentage than all other entries in the test. Four other SR progenies, 93HS27, 93HS37, 93HS35-8, and 92HS33 were equal to ACH 185 in sucrose percentage and RWST, Only two progenies were significantly lower than MH E4 for sucrose and RWST. Very little difference was noted in the CJP for the 22 entries. The smoothness scores ranged from 1.9 to 3.3 with, as expected, the commercial cultivars showing the highest scores. Unfortunately , SR progeny 93HS30 that had the highest sucrose percentage had poor root architecture, with a smoothness score no different than the commercial varieties. Three SR progenies (93HS35-8, 93HS35 and 93HS27) showed excellent performance when one considers breeding for the combined characteristics of smooth root architecture, high sucrose content and good root yield. Interesting observations were made for some SR entries of related parentage.

Progenies 93HS30, 93HS31, and 93HS37 all were derived from SR lines crossed to L19 inbred. Entry 93HS31 had high yield, and low sucrose content, while the two other progenies had the opposite, high sucrose content and low root yield. Entry 93HS32 and 93HS33 are similar except that 92HS33 also had some L53 germplasm in its background. Entry 92HS32 had high root weight and RWSA, while 92HS33 was considerably higher in sucrose content and RWST.

FIELD EVALUATION OF OPEN POLLINATED POPULATIONS OF SMOOTH ROOT BEETS WITH DISEASE RESISTANCE, OR MULTIPLE SOURCE SUCROSE ENHANCEMENT.

A field evaluation was made this year to assess the agronomic performance of 11 SR populations which had been derived from SR material crossed in previous years to other sugarbeet lines having good disease resistance or high sucrose content. There were 12 entries in the test; four (91HS1-00, 92HS11, 92HS13, 92HS14) were crosses of a selected SR genotype with lines having high sucrose content; three (92HS6, 92HS7, and 92HS8) were crosses of SR germplasm with Rhizoctonia and Cercospora leafspot resistant lines, and three (92HS10, 92HS12, 92HS15) were from SR lines crossed with multiple sources of high sucrose content. ACH 185 was included in the field trial as a check. The twelve entries were planted at the B&B Bean and Beet Research Farm on May 14, 1993. Plots were two rows 28″ apart and 30″ in length and there were six replicates of a random block design. The experiment was harvested and samples taken for sucrose and CJP using the same methods as cited previously.

RESULTS

RWSA, root weight, and CJP for the 12 entries were quite similar and they varied little from the performance of the check cultivar ACH 185. There were marked differences, however, for RWST, sucrose percentage and smoothness of root score (Table 3). Entry 92HS15, a population derived from the 8562 SR source crossed with high sucrose sources of L19, L53, and C51 showed the best performance. This SR composite had the highest RWSA and root weight of all of the entries and was among the highest in RWST, sucrose content and CJP percentage. It scored a 2.5 in smoothness in comparison to 3.5 for ACH 185 and 2.0 for entry 6, which had the lowest smoothness score and the most desirable root shape of all entries in the experiment. Entry 92HS10, with C40, L19, and L53 sugar sources in its parentage was excellent for sucrose content and RWST, but it was low in root yield, and RWSA and had a smoothness score no different than that of ACH 185. Entry 92HS13 and 92HS14 were other populations that showed excellent smoothness of root. Entry 92HS13 also had high CJP percentage and sucrose content 1% lower than the check.

EVALUATION OF EXPERIMENTAL HYBRIDS FROM CMS X SMOOTH ROOT GENOTYPES

In this experiment we evaluated the relative performance of four SR lines for combining ability when they were crossed to some of the same CMS inbred lines. Planting was made at the Bean and Beet Research Farm on May 14, 1993. The individual plots were two rows 28″ apart and 30′ in length in 4 replications of a random block design. ACH 185 was included as a check. Harvest was made on October 6, 1993 and data was collected in accord with standard procedure listed previously.

RESULTS

There was very little variation between the experimental SR hybrids with the exception for smoothness of root score (Table 4). ACH 185 was significantly better than all other entries for RWSA, RWST, and sucrose percentage. Only four SR hybrids, three of them being crosses with SR87, were significantly better than ACH 185 for smoothness of root score.

FIELD EVALUATION OF EIGHT ADVANCED SMOOTH ROOT GENOTYPES.

The agronomic performance of eight advanced SR breeding lines were compared with that of two commercial hybrid cultivars, MH E4 and ACH 185, and with two released sources of SR germplasm, SR87 and SR80, in a randomized block experiment of four replications. The entries were planted in two row plots 28″ apart and 30′ in length on May 14, 1993 at the B&B Research Farm. They were harvested on October 7, 1993 using the same procedures as outlined previously.

RESULTS

With the exception of 90HS2 and SR80, there was little difference between the RWSA of the commercial cultivars and the SR lines in this field trial (Table 5). These two lines were not only significantly lower in RWSA than both checks, but they were also lower than SR lines 91H1-00, and 89H700. Five of the SR lines had better root yield than ACH 185, but only one, 89H700, exceeded the root yield of MH E4. ACH 185 had higher sucrose percentage and RWST than all entries. Three of the SR lines, however, were equal to the MH E4 hybrid in their sucrose content and RWST. No differences were observed between the SR lines for CJP percentage, but SR87 and 89H700 were significantly lower in CJP percentage than ACH 185. Two of the SR lines, 89H700 and 91H5, had significantly lower root smoothness scores than SR87. The genotype 91H5 has promise for further breeding and selection, but 89H700 is too low in sucrose content (2.6% lower than ACH 185). Three additional SR lines, 90HS2, 90H3-00 and 90H11, also had significantly better root smoothness score than ACH 185. Unfortunately 90HS2 is extremely low in root yield and 90HS3-00 and 90H11 are low in sucrose content. In 1992 field trials, SR line 91H4 had equal RWSA, root weight and CJP percentage and only one percentage point less sucrose than ACH 185 and it was looked upon at that time as a potential SR release. (See 85131 select in table 3 of 1992 Research Report p. E14). However, this line did not maintain as favorable relationship to ACH 185 this year. A general observation is that lines with the highest sucrose content tended to have the lowest root smoothness score and those with excellent root shape were most often among the genotypes with the lowest sucrose.

Table 1. Sucrose yield, root yield, sucrose percentage, CJP percentage, and smoothness of root score for a group of high sucrose SR genotypes. B&B Farm 1993.

	Variety	Description	RWSA	RWST	T/A
1	92HS19	105[+]	4960 ab*	216.6 g	22.87 a
2	92HS10	112	4891 ab	246.5 b	19.89 ab
3	92HS25	105	4682 ab	237.1 bcde	19.74 ab
4	92HS29	104	4792 ab	238.1 bcd	20.22 ab
5	92HS30	102	5202 ab	240.1 bc	21.66 ab
6	92HS32	106	5364 a	236.4 cde	22.75 a
7	92HS33	113	5342 a	245.2 bc	21.83 ab
8	92HS34	106	4668 ab	228.2 ef	20.49 ab
9	92HS36	103	4844 ab	230.3 def	21.05 ab
10	92HS45	110	4498 b	226.6 f	19.86 ab
11	92HS46	110	4628 ab	239.8 bc	19.30 b
12	ACH 185	100	5326 a	258.2 a	20.61 ab
	Mean		4933	236.9	20.86
	lsd (0.05)		622	8.5	2.75
	CV		10.90	3.10	11.40

	Variety	Description	SUCR%	CJP%	Root SmSc
1	92HS19	105	16.03 f	91.42 c	2.2 cd
2	92HS10	112	17.60 b	92.61 a	2.8 ab
3	92HS25	105	16.97 cde	92.64 a	2.6 bcd
4	92HS29	104	16.94 de	92.89 a	2.1 d
5	92HS30	102	17.14 bcde	92.71 a	2.4 bcd
6	92HS32	106	16.99 cde	92.44 ab	2.0 d
7	92HS33	113	17.45 bc	92.77 a	2.8 bc
8	92HS34	106	16.72 e	91.68 bc	2.5 bcd
9	92HS36	103	16.67 e	92.21 ab	2.3 bcd
10	92HS45	110	16.20 f	92.82 a	1.4 e
11	92HS46	110	17.29 bcd	92.26 ab	3.4 a
12	ACH 185	100	18.41 a	92.55 a	3.4 a
	Mean		17.03	92.42	2.5
	lsd (0.05)		0.44	0.73	0.6
	CV		2.25	0.68	19.47

[+]Mean sucrose percentage relative to ACH 185 for seed parents individual beet selections.

* Duncan's Multiple Range Test - Means with the same letter suffix are not significantly different at the 0.05 level.

Table 2. Sugar yield, root yield, sucrose percentage, CJP percentage, and smoothness of root scores for SR selections made in the 1992 SR selection nursery. B&B 1993.

	Variety	Description	RWSA	RWST	T/A
1	93HS22	C40 X 8549-3	5269 abcde*	234.2 efg	22.50 abcde
2	93HS23	SR X AH27	5233 bcdef	236.8 defg	22.13 bcdef
3	93HS24-1	C40 X 85131-14	5734 ab	241.6 cdef	23.75 ab
4	93HS24-2	C40 X 85131-14	5258 bcde	246.1 bcde	21.37 cdefg
5	93HS25	92 HS SR COMP.	4762 fgh	242.6 bcde	19.70 ghi
6	93HS27	8580 X 28M3	5696 ab	251.5 bc	22.67 abcde
7	93HS28	85700-17X-28	5023 def	239.8 cdef	20.94 defgh
8	93HS29	C40,C51,L19X85700	5279 abcde	240.0 cdef	22.06 bcdef
9	93HS2	8549-38LINE	4201 i	229.9 fg	18.30 i
10	93HS30	SR X L19 F_1	4349 hi	266.0 a	16.43 j
11	93HS31	SR X L19 F_1	5453 abcd	234.0 efg	23.33 abc
12	93HS32	SR X C40,C51,L19	5532 abc	226.6 g	24.42 a
13	92HS33	SRXC40,C51,L19,L53	4792 efgh	247.1 bcd	19.40 ghi
14	93HS34	COMP. SRXC40	5766 a	234.6 defg	24.58 a
15	93HS35	COMP. SRXL19,C51	5617 abc	238.3 defg	23.59 ab
16	93HS37	SR X L19	4964 defg	245.7 bcde	20.23 fghi
17	93HR38	C51 X 85700	5185 cdef	226.4 g	22.95 abcd
18	93HS35-8	COMP. SRX28M3+	5651 abc	244.1 bcde	23.20 abc
19	93HS41	SR COMP.	4801 efgh	233.7 efg	20.59 efgh
20	93HS42	SR COMP.	4525 ghi	235.7 defg	19.19 hi
21	ACH 185		5402 abcd	254.2 b	21.27 cdefgh
22	MHI E4		4850 efg	241.9 cdef	20.06 fghi
	Mean		5152	240.5	21.48
	lsd (0.05)		421	10.4	1.84
	CV		7.14	3.79	7.47

Table 2. cont. Sugar yield, root yield, sucrose percentage, CJP percentage, and smoothness of root scores for SR selections made in the 1992 SR selection nursery. B&B 1993.

	Variety	Description	SUCR%	CJP%	Root SmSc
1	93HS22	C40 X 8549-3	16.73 gh*	92.76 abc	2.2 ef
2	93HS23	SR X AH27	16.92 efgh	92.70 abc	2.5 cdef
3	93HS24-1	C40 X 85131-14	17.37 cdef	92.35 abc	3.1 ab
4	93HS24-2	C40 X 85131-14	17.50 cde	92.81 abc	2.8 abcd
5	93HS25	92 HS SR COMP.	17.19 cdefg	93.02 ab	2.1 f
6	93HS27	8580 X 28M3	17.75 bc	93.08 a	2.3 def
7	93HS28	85700-17X-28	17.07 defg	92.83 abc	1.9 f
8	93HS29	C40,C51,L19X85700	17.07 defg	92.86 abc	2.3 def
9	93HS21	8549-38LINE	16.63 gh	92.22 abc	2.1 f
10	93HS30	SR X L19	18.70 a	93.09 a	3.2 ab
11	93HS31	SR X L19	16.83 fgh	92.46 abc	2.4 def
12	93HS32	SR X C40,C51,L19	16.42 h	92.19 abc	2.4 def
13	92HS33	SRXC40,C51,L19,L53	17.54 cde	92.88 abc	2.7 bcde
14	93HS34	COMP. SRXC40	16.81 fgh	92.64 abc	2.0 f
15	93HS35	COMP. SRXL19,C51	17.17 cdefg	92.29 abc	2.2 ef
16	93HS37	SR X L19	17.70 bc	92.22 abc	3.0 abc
17	93HR38	C51 X 85700	16.35 h	92.26 abc	2.4 def
18	93HS35-8	COMP. SRX28M3+	17.62 bcd	92.12 bc	2.1 f
19	93HS41	SR COMP.	16.95 efgh	92.04 c	2.1 f
20	93HS42	SR COMP.	16.80 fgh	92.83 abc	2.1 ef
21	ACH 185		18.16 b	92.48 abc	3.3 a
22	MHI E4		17.20 cdefg	92.86 abc	3.3 a
	Mean		17.20	92.59	2.5
	lsd (0.05)		0.52	0.74	0.5
	CV		2.66	0.70	17.51

Duncan's Multiple Range Test - Means with the same letter suffix are not significantly different at the 0.05 level.

Table 3. Sugar yield, root yield, sucrose percentage, CJP percentage and smoothness of root score for open pollinated populations of SR type with disease resistance and sucrose enhancement. B&B Farm 1993.

	Variety	Description	RWSA	RWST	T/A
1	ACH 185		5710 ab*	262.4 a	21.78 ab
2	91HS1-00	C40 x 85131-14 F2	5118 abc	222.4 f	23.02 a
3	92HS6-2	B18LSRxC40, 49-31,700	5228 abc	244.9 bc	21.37 ab
4	92HS7-2	B19RZ x L19,8549-38	5630 ab	236.7 de	23.78 a
5	92HS8-2	B18LSR x C40,85700	5306 abc	235.4 de	22.55 ab
6	92HS9-2	C564aa x 85700-17,-28	5213 abc	240.9 cd	21.64 ab
7	92HS10	C40 x 28M3,COE 8562	5036 bc	257.5 a	19.57 b
8	92HS11	L19 x 85131-22	4877 c	244.0 bc	20.01 b
9	92HS12	L19,C40,C51,46I,700	5639 ab	233.9 e	24.13 a
10	92HS13	C40 x 85700	5370 abc	249.3 b	21.56 ab
11	92HS14	8580 x 28M3	5371 abc	241.1 cd	22.28 ab
12	92HS15	C51x28M3, COE8562	5785 a	249.9 b	23.16 a
	Mean		5357	243.2	22.07
	lsd (0.05)		605	5.9	2.60
	CV		7.85	1.69	8.20

	Variety	Description	SUCR%	CJP%	Root SmSc
1	ACH 185		18.57 a	92.83 abc	3.5 a
2	91HS1-00	C40 x 85131-14 F2	16.22 f	91.96 d	2.6 bcd
3	92HS6-2	B18LSRxC40, 49-31,700	17.44 bc	92.74 abc	2.7 bcd
4	92HS7-2	B19RZ x L19,8549-38	17.00 de	92.48 bcd	2.5 bcd
5	92HS8-2	B18LSR x C40,85700	16.78 e	92.83 abc	2.9 abc
6	92HS9-2	C564aa x 85700-17,-28	17.01 de	93.21 ab	2.0 d
7	92HS10	C40 x 28M3,COE 8562	18.27 a	92.76 abc	3.3 ab
8	92HS11	L19 x 85131-22	17.31 cd	92.95 abc	2.6 bcd
9	92HS12	L19,C40,C51,46I,700	16.85 e	92.37 cd	2.6 bcd
10	92HS13	C40 x 85700	17.48 bc	93.43 a	2.3 cd
11	92HS14	8580 x 28M3	17.22 cd	92.68 abcd	2.3 cd
12	92HS15	C51x28M3, COE8562	17.68 b	92.99 abc	2.5 cd
	Mean		17.32	92.77	2.6
	lsd (0.05)		0.31	0.66	0.7
	CV		1.26	0.49	17.31

* Duncan's Multiple Range Test - Means with the same letter suffix are not significantly different at the 0.05 level.

Table 4. Sugar yield, root yield, sucrose percentage, CJP percentage, and smoothness of root score for experimental SR hybrids. B&B Farm 1993.

	Variety	Description	RWSA	RWST	T/A
1	ACH 185		6381 a*	258.3 a	24.80 a
2	90H12X01	FC607CMS X 8549-38	5256 b	222.2 b	23.62 a
3	90H12X02	576 CMS X 8549-38	5305 b	228.2 b	23.22 a
4	WC90013	576CMS X SR80	5121 b	229.2 b	22.46 a
5	WC90726	576CMS X SR87	5263 b	222.9 b	23.58 a
6	WC90728	FC607CMS X SR87	5170 b	222.6 b	23.28 a
7	WC90012	657CMS X SR80	4606 b	218.0 b	21.15 a
8	WC90727	657CMS X SR87	5487 b	220.1 b	24.94 a
9	WC92094	US H23 X 91HS10,+11	4861 b	226.3 b	21.55 a
10	WC92093	657CMS X 91HS10,+11	5108 b	221.3 b	23.09 a
11	WC92095	576CMS X 91HS10,+11	5370 b	227.7 b	23.61 a
12	WC92092	FC607CMS X 91HS10,11	5127 b	225.3 b	22.81 a
Mean			5255	226.8	23.18
	lsd (0.05)		869	11.3	3.70
	CV		11.49	3.46	11.11

	Variety	Description	SUCR%	CJP%	Root SmSc
1	ACH 185		18.27 a	92.89 a	3.5 a
2	90H12X01	FC607CMS X 8549-38	15.81 bc	93.14 a	3.0 abc
3	90H12X02	576 CMS X 8549-38	16.17 bc	93.23 a	3.1 ab
4	WC90013	576CMS X SR80	16.38 b	92.80 a	3.4 a
5	WC90726	576CMS X SR87	15.99 bc	92.72 a	2.6 bc
6	WC90728	FC607CMS X SR87	15.98 bc	92.69 a	2.4 c
7	WC90012	657CMS X SR80	15.72 c	92.56 a	3.1 ab
8	WC90727	657CMS X SR87	15.92 bc	92.40 a	2.4 c
9	WC92094	US H23 X 91HS10,+11	16.18 bc	92.81 a	2.6 bc
10	WC92093	657CMS X 91HS10,+11	15.97 bc	92.45 a	3.0 abc
11	WC92095	576CMS X 91HS10,+11	16.33 bc	92.66 a	3.1 ab
12	WC92092	FC607CMS X 91HS10,11	16.17 bc	92.66 a	3.3 ab
Mean			16.24	92.75	2.9
	lsd (0.05)		0.53	0.90	0.60
	CV		2.28	0.68	14.20

* Duncan's Multiple Range Test - Means with the same letter suffix are not significantly different at the 0.05 level.

Table 5. Sugar yield, root yield, sucrose percentage, CJP percentage, and smoothness of root score for elite SR genotypes. B&B Farm 1993.

	Variety	Description	RWSA	RWST	T/A
1	ACH 185		5318 a*	256.4 a	20.77 de
2	MHI E4		5355 a	235.0 b	22.77 bcd
3	SR87	SR87	4983 abc	202.3 d	24.63 ab
4	SR80	SR800	4584 bc	222.5 bc	20.62 de
5	89H700	700 Line	5396 a	208.9 cd	25.89 a
6	92HS7-1	SRHSRZ	4977 abc	222.5 bc	22.37 bcde
7	92HS35		4384 c	223.2 bc	19.70 e
8	91H5	85700-18X-28	5389 a	226.1 b	23.82 abc
9	91H4	85131-16	4891 abc	227.4 b	21.48 cde
10	91H1-00	C40 x 700-38,27,-17	5427 a	226.3 b	23.98 abc
11	90H3-00	8549-38 X L19	5152 ab	221.6 bc	23.24 abcd
12	90H11	SR x L53/US35	5138 ab	209.1 cd	24.59 ab
	Mean		5083	223.4	22.82
	lsd (0.05)		600	13.7	2.49
	CV		8.20	4.26	7.57

	Variety	Description	SUCR%	CJP%	Root SmSc
1	ACH 185		17.93 a	93.44 a	3.2 ab
2	MHI E4		16.79 b	92.73 ab	3.5 a
3	SR87	SR87	14.92 e	91.78 b	2.1 d
4	SR80	SR800	16.04 bcd	92.50 ab	2.8 bcd
5	89H700	700 Line	15.34 cde	91.89 b	1.4 e
6	92HS7-1	SRHSRZ	16.00 bcd	92.73 ab	3.2 ab
7	92HS35		16.19 bc	92.20 ab	2.2 cd
8	91H5	85700-18X-28	16.04 bcd	93.20 ab	1.5 e
9	91H4	85131-16	16.52 b	92.07 ab	2.8 bc
10	91H1-00	C40 x 700-38,27,-17	16.22 b	92.69 ab	2.6 bcd
11	90H3-00	8549-38 X L19	15.99 bcd	92.47 ab	2.2 cd
12	90H11	SR x L53/US35	15.28 de	92.09 ab	2.3 cd
	Mean		16.10	92.48	2.5
	lsd (0.05)		0.76	1.31	0.6
	CV		3.30	0.99	15.93

* Duncan's Multiple Range Test - Means with the same letter suffix are not significantly different at the 0.05 level.

FIELD EVALUATION OF THE RELATIVE PERFORMANCE AND COMBINING ABILITY OF AN AGRONOMIC SELECTION FROM L19 VERSUS L19.

J.C. Theurer

L19 inbred has outstanding sucrose content, but it also harbors some undesirable characteristics. Many of the plants have multiple crowns and taproots are frequently deep grooved and/or too small in size. A selection of approximately 100 roots with single crowns, good root shape and root size equal to the mean of the parent line was made from a field planting in 1991 in an attempt to improve the agronomic characteristics of L19. Seed increase was made of the selected roots and at the same time CMS lines were also planted within the isolation block to obtain F1 hybrids to evaluate the combining ability of the new L19 selection. Five experimental hybrids, L19, L19 Select, and two commercial hybrid cultivars, MH E4 and ACH 185 were planted May 14th in a field experiment at the Bean and Beet Research Farm near Saginaw, MI in 1993. The nine entries were planted in two row plots with rows 28″ apart and 30′ in length and there were six replications. The experiment was harvested on October 7, 1993 using methods as outlined in Experiment 931 above.

RESULTS

The nine entries formed two groupings for RWSA (Table 8). MH E4, and the two L19 inbreds were significantly lower in RWSA than the other six entries. The L19 lines and ACH 185 had the highest sucrose percentage and RWST. WC91269, a BMC CMS x L19 Select hybrid, was highest in root yield and also the entry with the lowest sucrose content. WC91268 (576CMS crossed to L19 Select), showed the best combining ability of the experimental hybrids for sucrose content and CJP percentage. MH E4 was lowest in amino N in the root at harvest and the two L19 lines and WC91269 were highest in amino N. Although there were no significant differences between the L19 lines for any of the variables measured, there were indications showing a trend for change due to the selection pressure. L19 Select tended to show higher RWSA and yield, lower sucrose percentage, amino N, and higher CJP percentage than the L19 parent line. There was no apparent relationship between sucrose content and the meq amino N per 100g sucrose in the beet root. L19 and L19 Select exhibited high sucrose content and high amino N. ACH 185 showed high sucrose and relatively low amino N. WC91269 had low sucrose and high amino N. These results suggest that L19 and BMC plant material might be useful to study more fully the genetic and physiological relationship of sucrose accumulation and the retention of nitrogen impurities in the beet root.

Table 1. Sucrose yield, root yield, sucrose percentage, CJP percentage and meq amino N/ 100 grams sucrose for L19, L19 Select, and experimental CMS hybrids with L19 Sel. as a parent. B&B Farm 1993.

1993 Combining Ability of High RWST Selection of L19 Germplasm

	Variety	Description	RWSA	RWST	T/A
1	MHI E4	MHI E4	4760 b*	256.9 cde	18.56 b
2	ACH 185	ACH 185	5421 a	264.6 bc	20.51 ab
3	WC91266	H23CMSxL19 Sel.	5514 a	252.2 de	21.92 a
4	WC91267	657CMSxL19 Sel.	5271 a	252.1 de	20.90 ab
5	WC91268	576CMSxL19 Sel.	5345 a	260.6 cd	20.54 ab
6	WC91269	BMC CMSxL19 Sel.	5469 a	246.3 e	22.27 a
7	WC91270	FC607CMSxL19 Sel.	5541 a	255.2 cde	21.74 a
8	WC91270M	L19 Sel.	4462 b	272.8 ab	16.38 c
9	90L19	L19	4340 b	278.0 a	15.62 c
	Mean		5125	259.9	19.83
	lsd (0.05)		473	10.8	2.17
	CV		7.92	3.56	9.39

	Variety	Description	SUCR%	CJP%	Amino N meq/100g
1	MHI E4	MHI E4	17.99 bc	93.39 a	8.51 c
2	ACH 185	ACH 185	18.63 b	93.06 ab	9.61 bc
3	WC91266	H23CMSxL19 Sel.	18.02 bc	92.51 bc	10.05 bc
4	WC91267	657CMSxL19 Sel.	18.23 bc	91.95 c	8.77 bc
5	WC91268	576CMSxL19 Sel.	18.46 bc	92.80 ab	9.71 bc
6	WC91269	BMC CMSxL19 Sel.	17.91 c	91.78 c	13.54 a
7	WC91270	FC607CMSxL19 Sel.	18.16 bc	92.67 ab	9.43 bc
8	WC91270M	L19 Sel.	19.44 a	92.40 bc	11.55 ab
9	90L19	L19	20.02 a	91.89 c	13.61 a
	Mean		18.54	92.49	10.53
	lsd (0.05)		0.59	0.66	2.61
	CV		2.71	0.61	21.20

* Duncan's Multiple Range Test - Means with the same letter suffix are not significantly different at the 0.05 level.

RHIZOCTONIA ROOT ROT EVALUATION FOR COMMERCIAL AND EXPERIMENTAL HYBRIDS AT EAST LANSING, MI. 1993

J. C. Theurer, Lee Hubble and J. M. Halloin

Eighteen hybrid varieties plus two resistant checks, FC 710/5 and FC 712, and two susceptible checks, USH 23, and Universe were evaluated for their resistance to Rhizoctonia root rot in the disease nursery maintained at E. Lansing, MI. The natural source of inoculum in the soil was supplemented with an application of ground millet infected with R. solani, which was applied to the crowns of the beets just prior to layby. The roots were dug by hand in early November and scored for disease on a scale of 0 = no infection lesions to 4 = dead plant. There was only moderate infection in the nursery this year. In previous years, Univers was the most susceptible variety and FC 712, was the most resistant entry in the test.

Table 1. 1993 Commercial and experimental Variety Rhizoctonia Evaluation, USDA Disease Nursery. East Lansing, MI.

Code No.	Variety	RZ Score	% Diseased Plants
3	Beta 5282	3.08 a*	77.05 a
17	Beta 5603	3.02 ab	75.57 ab
10	ACH 89-370	2.99 abc	74.62 abc
16	MH E9	2.94 abcd	73.53 abcd
20	Univers - Susc.	2.85 abcde	71.28 abcde
1	ACH 89-417 (ACH-319)	2.72 abcdef	68.07 abcdef
4	ACH 185	2.72 abcdefg	67.94 abcdefg
14	Beta BG6914	2.70 abcdefg	67.46 abcdefg
12	SX 1101	2.69 abcdefg	67.36 abcdefg
13	HM 2717	2.67 abcdefgh	66.67 abcdefgh
7	SX 1103	2.65 abcdefghi	66.17 abcdefghi
9	MH E10	2.62 bcdefghi	65.47 bcdefghi
8	ACH 308	2.56 cdefghi	64.03 cdefghi
5	MH E4	2.56 cdefghi	63.96 cdefghi
2	HM 2718	2.54 cdefghi	63.55 cdefghi
19	USH23 - Susc.	2.51 defghi	62.73 defghi
6	Beta 5315	2.43 efghi	60.76 efghi
11	Beta 5931	2.29 fghi	57.32 fghi
15	ACH 197	2.27 fghi	56.69 fghi
18	ACH 89-390	2.26 ghi	56.56 ghi
21	WC90318 - Res.	2.23 hi	55.83 hi
22	FC 712 - Res.	2.20 i	54.93 i
MEAN		2.61	65.34
lsd 0.05		0.38	9.49
C.V.		10.28	10.28

* Duncans Multiple Range Test - Means with same letter are not significant at the 0.05 level.

POTENTIAL BIOCONTROL OF RHIZOCTONIA ROOT ROT

J. C. Theurer and J. M. Halloin

In 1992 a comparison of 12 genotypes varying in Rhizoctonia resistance from highly susceptible to highly resistant gave evidence that there was some biocontrol for Rhizoctonia root rot(See 1992 Research Report p.E28). In 1993 we repeated the experiment. Twelve genotypes were planted on land (L1) that had been used for Rhizoctonia evaluation for several years, and on land (L2) outside the disease nursery but of similar soil type and only 300 meters from L1 at the Botany Research Farm at East Lansing. Six replications of the 12 entries were planted in single rows 28" apart and 25' in length. Special effort was taken again this year to provide as identical management practices as possible for the L1 and L2 units. The roots were dug by hand in early November and scored for disease on a scale of 0 = no infection lesions to 4 = dead plant. There was only moderate infection in the nursery this year. No differences were visually observed on the tops and crowns of the beets between L1 and L2. Significant differences were observed for genotypes, but the genotype x location interaction was non-significant (Table 2). This years results fail to confirm the 1992 conclusion that biocontrol of Rhizoctonia resistance has occurred in L1.

Table 2. Rhizoctonia root rot mean scores and percent diseased plants for 12 genotypes grown on land used many years as a Rhizoctonia disease nursery (L1) versus on land not previously used for Rhizoctonia evaluation (L2). East Lansing, MI. 1993.

Genotype	Root Rot Score		Percent diseased plants	
	L1	L2	L1	L2
1. FC 712	2.38	1.82	59.5	45.5
2. FC 701/5	1.96	1.94	48.9	48.4
3. 91H2-00	2.76	3.08	68.9	77.1
4. 87B3-33	1.92	2.26	48.0	56.6
5. 85320-0	3.45	3.36	86.3	84.0
6. 85259-80	2.62	2.33	65.5	58.3
7. 88B22-00	3.32	3.20	83.1	80.1
8. 86B18-124	2.52	2.44	62.9	61.0
9. 88B12	2.49	2.21	62.2	55.2
10. Universe	2.55	3.11	63.7	77.8
11. USH 23	2.90	3.01	72.6	75.3
Location:				
MEAN	2.62	2.62	65.6	65.4
lsd (0.05)	0.60	0.44	14.9	11.1
Experiment:				
MEAN	2.62		65.48	
lsd (0.05)	0.52		13.01	

Cercospora Leafspot Evaluation of Smooth Root Selection Blocks, Experimental And Commercial Varieties Made at East Lansing 1993.

J. C. Theurer and R. C. Zielke

A disease nursery has been used at East Lansing, MI for many years to evaluate and select breeding material which has resistance to Cercospora leafspot. The results of evaluations for a group of commercial hybrids, seed furnished by R. C. Zielke, and eight selection blocks of SR progenies, are given in this report. The commercial varieties were each planted in a randomized block experiment of 4 replications. Individual plots were single rows, 28" apart and 25' in length. The SR selection blocks consisted of 6 rows 28" apart and 25' in length. ACH 185 and the high leafspot resistant East Lansing line 86403 were planted adjacent to the selection blocks to serve as check varieties. When the full leaf canopy was developed on the beet plants, the nursery was inoculated by hand dusting with finely ground Cercospora infected leaves collected from the 1992 leafspot disease nursery. High humidity was maintained for 10 days after inoculation to enhance leafspot development by frequent misting of leaves using a sprinkler irrigation system with five nozzles.

Each plot in the disease nursery was scored for leafspot infection, five times during August and September. Only the final reading made on September 23, is shown in the tables in this report. Scores are on a 0 = no infection to 9 = dead plant basis.

Excellent infection occurred and significant difference in disease severity between genotypes was noted. Results for the SR selection blocks are shown in table 1 and for the commercial and experimental varieties in table 2. We plan to release WC 86403 as EL 50.

Table 1. Cercospora leafspot reading for a group of SR progenies. Leafspot nursery selection.

Blocks - 1993		
Progeny No.	Description	Leafspot Score+
93H1-1	SR80-20	1.63
93H1-2	SR80-14	1.91
93H3-1	SR87-6	2.58
93H3-2	SR87-2	2.33
93H5-1	SR-EL Line Composite	2.31
93H5-2	SR-EL Line Composite	2.29
93H5-3	SR-EL Line Composite	1.63
93H21-5	91H6 SR	1.50
WC 86403	LSR Res. Check	1.00
ACH 185	Commercial Check	3.33

+ Based on 1-9 scale where 0 = no symptoms and 9 = dead plant

Table 2. Leafspot scores for commercial and experimental hybrid varieties. September 23, 1993 Reading.

Variety	Leafspot Score
SX 1104	6.38 a*
VDH OVATIO	6.00 ab
VDH SUPRAFOR	5.75 abc
US H20	5.50 bcd
BETA 5282	5.50 bcd
HMI 2717	5.25 bcde
SX 1208	5.25 bcde
BETA BG6914	5.13 cdef
HMI 2718	5.13 cdef
AC-92-185	5.13 cdef
93HX131	4.75 defg
HMI 2716	4.75 defg
SX 1209	4.75 defg
BETA 5603	4.63 defgh
ACH 308	4.63 defgh
BETA BG6912	4.63 defgh
HMI E10	4.63 defgh
93HX129	4.63 defgh
BETA BG5312	4.63 defgh
HMI 2720	4.63 defgh
ACH 185	4.50 efghi
SX 1207	4.50 efghi
AC-92-179	4.35 efghi
HMI E9	4.25 fghij
BETA 5931	4.13 ghijk
ACH 319	4.00 ghijkl
BETA 5315	4.00 ghijkl
ACH-89-390	3.83 hijklm
ACH-89-370	3.75 hijklmn
HMI 2719	3.75 hijklmn
HMI E4	3.63 ijklmno
BETA BG5303	3.63 ijklmno
AC-92-173	3.63 ijklmno
BETA 5639	3.38 jklmnop
HMI E7	3.38 jklmnop
BETA 5823	3.25 klmnop
AC-92-165	3.25 klmnop
AC-92-154	3.13 lmnop
BETA BG5359	3.00 mnop
AC-92-159	3.00 mnop
ADH 197	2.88 nop
93HX130	2.83 op
BETA BG4501	2.63 p
WC86403	1.63 q

* = Means with same suffix letter are not significantly different at the 0.05% level using Duncan's multiple range test.

SUGARBEET RESEARCH

1993 Report

Section F

University of Idaho
Idaho

Dr. S. L. Hafez

The research was supported in part by funds provided through the University of Idaho and the Beet Sugar Development Foundation.

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THE USE OF GREEN MANURE CROPS IN SUGARBEET ROTATION FOR NEMATODE MANAGEMENT

Saad L. Hafez

At least 29 species of plant parasitic nematodes within 16 genera can affect sugarbeet production. The overall sugarbeet yield losses attributed to nematodes is estimated to be in the range of 10-70%. The sugarbeet cyst nematode *Heterodera schachtii* account for most of the loss. Nematologists and plant pathologists agree that nematode are the major pest affecting sugarbeet production everywhere beets are grown commercially. The most common practices for sugarbeet nematode management is the use of nematicides (chemical control) at a cost of $100 to $300 per acre. The future availability of the most commonly used nematicides is uncertain because of health and environmental concern. These have come under attack by several environmental groups. Also there is a great public concern over the toxic hazards of these materials. Therefore, research emphasis needs to be directed towards developing environmentally safe alternative methods for sugarbeet nematode management.

A promising approach is the use of trap crops; plants that allow penetration yet are poor hosts for the nematode. Various plants with potential as trap crops have been shown to stimulate hatch, including sugarbeet (*Beta vulgaris*), oilseed radish (*Raphanus sativus* var. *oleifera*), white mustard (*Sinapis alba*), and buckwheat (*Fagopyrum esculentum*). Nematode-resistant cruciferous crops, particularly oilseed radish, may be useful as crop rotations that reduce *H. schachtii* populations. Cultivars of oilseed radish, white mustard, and buckwheat that stimulate hatch and depress *H. schachtii* reproduction have been developed in Europe. The research presented here was conducted to assess the usefulness of these cultivars for *H. schachtii* management in sugarbeet production.

I. THE EFFECT OF OIL RADISH AND MUSTARD VARIETIES FALL PLANTED IN INFESTED FIELD ON SUGARBEET CYST NEMATODE *Heterodera schachtii* POPULATION.

Seven varieties of oil radish (*Raphanus sativus* var. *oleifera*) and white mustard (*Sinapis alba*) were planted following wheat in sugarbeet cyst nematode infested field in the fall of 1992 in Parma, Idaho. Each variety was replicated four times in a complete randomized block design and a fallow treatment was included as a control check for comparison. All varieties were mechanically chopped three months after planting. Roots and forages were incorporated in the soil by double disking. Soil samples before planting in the fall and in the following spring were collected for nematode assay. Results of nematode assay indicated that all varieties reduced the total number of eggs and larvae significantly (Table 1). Oil radish (Adagio var.) causes the highest % of reduction in comparison to fallow (51%). White mustard (Martigena var.) causes the lowest % of reduction (21%). The same test was repeated in the fall of 1993 at the same location to confirm results obtained in 1992-1993.

II. THE EFFECT OF DIFFERENT OIL RADISH AND MUSTARD VARIETIES FALL PLANTED ON SUGARBEET ROOT YIELDS PLANTED IN THE FOLLOWING SEASON IN HEAVILY INFESTED FIELD.

Sugarbeet variety HM-WS-90 was planted following the oil radish and white mustard to evaluate their effect on sugarbeet yield. No nematicides were added to this field and standard insecticides for maggot control were applied at planting. Results showed that most oil radish and mustard varieties increased the sugarbeet yield significantly in comparison with the fallow treatment (Table 2).

III. THE EFFECT OF DIFFERENT OIL RADISH AND MUSTARD VARIETIES ON SOIL NUTRIENT LEVELS.

Incorporating root and forage of the green manure crops will add substantial amount of humus which will enhance soil biological activity. Also, added humus substances to soil will enhance the activity of beneficial organisms and these will enhance soil fertility. Soil analysis before planting the green manure crops and after its incorporation showed significant improvement in soil fertility levels as shown in Tables 3 and 4.

The other secondary benefit observed in the green manure plots was that the weed population was reduced significantly where oil radish and white mustard were growing.

Table 1. The effect of different oil radish and mustard varieties planted in the fall on sugarbeet cyst nematode Heterodera schachtii population. Parma, 1992-93.

Oil Radish or	Viable Cyst		Total Eggs & Larvae		%
Mustard Var.	8/6/92	4/20/93	8/6/92	4/20/93**	Reduction
Adagio Radish	16.8	3.0	2,167	171	92
Ultimo Radish	15.3	4.5	2,010	225	89
Remonta Radish	9.0	2.5	936	110	88
Pegletta Radish	11.5	2.5	1,484	193	87
Metex Mustard	12.5	3.0	1,288	201	84
Maxi Mustard	8.5	2.8	1,139	235	79
Martigena Mustard	11.5	8.0	1,806	688	62
Fallow control	6.8	5.5	1,149	679	41

*Average of 4 replications
**8/6/92 = Before planting the green manure crops.
4/20/93 = Before planting sugarbeets.

Table 2. **The effect of different oil radish and mustard varieties planted in the fall on sugarbeet yield planted in the following season. Parma, 1993.**

Oil Radish or mustard var.	Sugarbeet Root yield T/A	Sugarbeet yield increase T/A	% of sugar
Radish Adagio	31.4 a*	9.3	17.01
Mustard Metex	29.1 a	7.0	17.20
Radish Pegletta	28.6 a	6.5	16.91
Radish Ultimo	28.2 a	6.1	16.45
Mustard Maxi	28.1 a	6.0	16.80
Radish Remonta	27.6 a	5.5	17.35
Mustard Martigena	25.9 b	3.8	17.13
Fallow control	22.1 b	--	17.37

*Average of 4 replications.

Table 3. The effect of different oil radish and mustard varieties on soil nutrient levels (ppm - N, P, K, Ca).

Variety (crop)	Nitrate NO3 - N		Phosphorus P		Potassium K		Calcium Ca	
	Before	After	Before	After	Before	After	Before	After
R. Adagio	21	19	19	11	197	272	3590	5160
R. Pegletta	23	23	18	22	249	290	4506	2522
M. Metex	17	23	19	21	231	268	3978	5260
M. Maxi	22	22	18	13	176	295	3590	5541
R. Remonta	19	21	15	21	199	241	3872	5475
M. Martigena	31	21	14	13	220	274	3626	5240
R. Ultim	22	28	23	19	248	275	3661	5860
No Plant	23	19	23	19	195	288	3238	5430

Table 4. The effect of different oil radish and mustard varieties on soil nutrient levels (ppm - Na, Zn, Fe, and pH, % lime).

Variety	Sodium Na		Zinc Zn		Iron Fe		pH		% Lime	
	Before	After	Before	After	Before	After	Before	After	Before	After
R. Adagio	294	118	0.6	1.0	75.0	9.8	8.2	7.9	7.5	8.0
R. Pegletta	355	99	0.7	0.9	60.0	9.4	8.4	8.0	9.5	7.0
M. Metex	364	114	0.8	0.9	15.0	9.8	8.4	8.2	7.5	5.0
M. Maxi	274	127	0.9	1.0	15.0	10.8	8.3	8.1	10.0	5.0
R. Remonta	289	101	0.6	0.9	30.0	9.4	8.4	8.2	8.5	6.0
M. Martigena	348	116	0.6	1.0	45.0	9.4	8.3	8.1	12.0	6.0
R. Ultim	369	108	0.6	1.0	15.0	10.1	8.4	8.0	8.5	7.0
No Plant	299	96	0.7	0.9	15.0	10.1	8.5	7.9	12.0	6.0

SUGARBEET RESEARCH

1993 Report

Section G

Texas Agricultural Experiment Station
Bushland, Texas

Dr. C. M. Rush
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Cooperation:

Imperial Holly - Hereford, Texas

The research was supported in part by funds provided through the Texas A&M University and the Beet Sugar Development Foundation (Project 503 and 520).

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HARVESON, R. M. and C. M. RUSH. 1993. The effect of Aphanomyces root rot and Rhizomania on sugar beet in a controlled environment. 27th Bien. Mtg. Amer. Soc. Sugar Beet Technol., Anaheim, CA, March 3-6, 1993.

An experiment was conducted to determine the effect of *Aphanomyces cochlioides* and beet necrotic yellow vein virus (BNYVV), the causal agents of Aphanomyces root rot and rhizomania, respectively, on sugar beets. The test was performed in a controlled temperature box that was maintained at 27 ± 2 C. Four treatments were employed, and consisted of soil containing Aphanomyces, BNYVV, both pathogens combined, and an uninfested control. Leaf weights and areas were taken twice during the test, at two and three months after planting. At harvest, tops were removed and the root profile was divided into equal 15-cm segments and washed. Roots collected from each segment were dried and weighed. At the time of the first reading for leaf weight and area, the control treatment was significantly different from the pathogen treatments. By the end of the test, significant differences were seen only between control and the treatment involving both pathogens. More damage was observed in dry top weight and taproot weight with the combined pathogen than with either one alone. Although the root rot rating for *A. cochlioides* was more severe than that of BNYVV, there was less weight reduction in the taproot. Root distribution was affected by pathogen treatments. In all segments, a greater amount of roots were recovered from uninfested controls than in all other treatments. In the middle segment, BNYVV produced more roots than *A. cochlioides*, but no differences were seen between the pathogen treatments in the bottom segment.

HARVESON, R. M. and C. M. RUSH. 1993. Movement of viruliferous *Polymyxa betae* from a point source inoculation. 27th Bien. Mtg. Amer. Soc. Sugar Beet Technol., Anaheim, CA, March 3-6, 1993.

Research was initiated in 1992 to study the spread of viruliferous *Polymyxa betae* from a known point source inoculation by irrigation and soil tillage. Untreated HH39 sugar beet seeds were planted 14 May 1992 in four 30 x 100 ft. borders, each containing twelve 30-inch beds. Inoculated seeds, used to establish the point source of infested soil, were obtained by coating seeds with a mixture of 2% methyl cellulose and powdered sugar beet roots containing BNYVV-infested *P. betae* cystosori. They were placed in the first ten feet of the two outside rows of each border. Half the plots were irrigated twice a month, and the other half once a month. Plant samples were collected twice and assayed by ELISA for BNYVV incidence. Soil samples were also collected and assayed. At the end of the first year, very little movement of BNYVV was detected outside of the inoculated areas. Establishing infection in the plots was successful because BNYVV was detected from the point source areas

in every assay. Future research will include collecting and assaying soil samples after land preparation for 1993, and repeating 1992 irrigation effect.

HEIDEL, G. B. and C. M. RUSH. 1993. Distribution of beet necrotic yellow vein virus, beet distortion mosaic virus, and an unnamed soilborne sugar beet virus in Texas and New Mexico. Plant Dis. (Accepted for publication).

The Texas sugar beet-growing area was surveyed to determine the incidence of beet necrotic yellow vein virus (BNYVV), beet distortion mosaic virus (BDMV) and an unnamed soilborne sugar beet virus designated as Texas 7 (Tx7). In late 1990, 302 soil samples were collected from seven Texas counties and one New Mexico county from fields scheduled for 1991 production. Sugar beet seed was planted in the soil samples, and root tissue was later harvested and tested by ELISA. Of 174 soil samples screened for BNYVV, 19 were positive. Of 128 samples tested for BNYVV and Tx7, 12 were positive for Tx7, 3 were positive for BNYVV and 23 were positive for both BNYVV and Tx7. One hundred fifty-nine soil samples were collected around symptomatic beets in 1991. Root tissue from sugar beets grown in the soil samples were tested for BNYVV, Tx7 and BDMV. Twenty samples were positive for Tx7, 27 were positive for BNYVV and 37 were positive for both Tx7 and BNYVV. Twelve of 72 sugar beets pulled at the time soil samples were collected were positive for BDMV. Sugar beets grown in soil samples collected from 8 of the 10 Texas sugar beet-growing counties were positive for BNYVV. Tx7 and BDMV were identified in the three major Texas sugar beet-growing counties. BDMV was identified in one New Mexico county. This is the first report of BDMV in New Mexico. No soil samples, including those collected directly around beets positive for BDMV, were positive for BDMV.

HEIDEL, G. B. and C. M. RUSH. 1993. Incidence of beet necrotic yellow vein virus, beet distortion mosaic virus, and an unnamed soilborne sugar beet virus in Texas. 27th Bien. Mtg. Amer. Soc. Sugar Beet Technol., Anaheim, CA, March 3-6, 1993.

The Texas sugar beet growing area was surveyed to determine the incidence of beet necrotic yellow vein virus (BNYVV), beet distortion mosaic virus (BDMV), and an unnamed soilborne sugar beet virus designated as Texas 7. In late 1990, Holly agronomists collected 302 soil samples from seven Texas counties and one New Mexico county from fields scheduled for 1991 production. Sugar beet seed was planted in the soil samples. Nine to ten weeks later, root tissue was harvested and tested by ELISA. Of 174 soil samples screened for BNYVV, 11% were positive. Of 128 samples tested for BNYVV and Texas 7, 8% were positive for Texas 7, 2% were positive for BNYVV and 17% were positive for BNYVV and Texas 7. One hundred fifty-nine soil samples were collected around symptomatic beets in 1991 and screened for BNYVV, Texas 7, and BDMV. Thirteen percent were positive for Texas 7, 16% were positive for BNYVV, and 23% were positive for Texas 7 and BNYVV. Seventeen percent of beets pulled at the time soil samples were collected were

positive for BDMV. Soil samples collected from 9 of the 10 Texas sugar beet-growing counties were positive for BNYVV. Texas 7 was identified in the three major Texas sugar beet-growing counties. BDMV was identified in four Texas counties and one New Mexico county. This is the first report of BDMV in New Mexico. No soil samples, including those collected directly around beets positive for BDMV, were positive for BDMV. BDMV is probably not a soilborne virus.

HEIDEL, G. B., C. M. RUSH, T. L. KENDALL, and S. A. LOMMEL. 1993. Partial characterization of a soilborne sugar beet virus in Texas. 27th Bien. Mtg. Amer. Soc. Sugar Beet Technol., Anaheim, CA, March 3-6, 1993.

Texas 7 is an unnamed soilborne sugar beet virus that was reported in Texas in 1988. It is morphologically similar to beet necrotic yellow vein virus (BNYVV) and is transmitted by *Polymyxa betae*. BNYVV and Texas 7 differ serologically. Foliar symptoms in sugar beets can include broad chlorotic areas along the veins. Leaves are not always symptomatic. Characterization studies were initiated to gather preliminary information on morphological, physiochemical and biological properties. Particle lengths fall between 50 and 300 nm, with more frequent values occurring at 50, 100, 210 and 290 nm. Coat protein molecular weight was estimated at 24 kDa by SDS-polyacrylamide gel electrophoresis. RNA was separated by formaldehyde gel electrophoresis. Four RNA species of approximately 6.6, 4.4, 1.2 and 1.0 kb were observed. Texas 7 RNA 1 and RNA 2 are close in size to BNYVV RNA 1 and RNA 2 (6.8 and 4.7 kb, respectively). Texas 7 RNA was applied to an oligo (dT)-cellulose column. Bound fractions were eluted from the column and electrophoresed on a non-denaturing agorose gel. Three polyadenylated RNA species were observed. No serological relationship was observed between BNYVV and Texas 7 in Western blots. Some BNYVV and Texas 7 virus particles were bound by heterologous antiserum in immunospecific electron microscopy. Texas 7 hosts include spinach, *Chenopodium quinoa, Beta macrocarpa,* and *Beta maritima.*

LINDSTEN, K. and C. M. RUSH. 1993. First report of beet soilborne virus in the United States. Plant Dis. Note (In press).

The furovirus beet soilborne virus (BSBV), first reported in England in 1982, is vectored by *Polymyxa betae* Keskin and has been identified from sugar beet-growing areas throughout western Europe. BSBV is similar in size and shape to beet necrotic yellow vein virus (BNYVV), the cause of rhizomania of sugar beet, but BSBV is less virulent. Sugar beet, the only identified natural host of BSBV, is frequently a symptomless host, and the actual effects of BSBV on sugar beet are unknown. To determine whether BSBV was present in the United States, three to five sugar beet plants were individually transplanted into each of 19 soil samples taken from sugar beet fields in Texas; five from Colorado; four each from Minnesota, Idaho, Nebraska, and Wyoming; and 10 from California. After 1 or 2 wk, bait plants were harvested and tested by DAS-ELISA for BSBV. Root sap was also mechanically inoculated to

Chenopodium quinoa Willd., a local lesion host of BSBV. More than 50% of soil samples tested from each state were positive for BSBV. Characteristic symptoms of BSBV also developed on inoculated leaves of *C. quinoa*. This is the first report of BSBV in the United States and confirms that the virus is widespread in sugar beet-growing areas in this country.

RUSH, C. M., D. E. CARLING, R. M. HARVESON, and J. T. MATHIESON. 1993. Prevalence and pathogenicity of anastomosis groups of *Rhizoctonia solani* from wheat and sugar beet in Texas. Plant Dis. (In press).

Ninety-eight isolates of *Rhizoctonia spp.*, primarily *R. solani*, were isolated from wheat and sugar beets grown in the Texas Panhandle and typed for anastomosis group (AG). Eighty-nine percent of the 46 isolates from mature beet were AG2-2, 95% of the 45 isolates from wheat were AG4, and most of the isolates (7) obtained from beet seedlings were either AG4 or AG5. Two isolates of binucleate *Rhizoctonia sp.* also were recovered, one from mature sugar beet and one from beet seedlings. Randomly selected isolates from each AG were capable of colonizing wheat, corn, cotton, and sorghum residue saprophytically, and optimum temperature for growth of most isolates was between 20-30 C. In pathogenicity studies, isolates of AG2-2 and AG4 reduced emergence and final stand of sugar beet seedlings, and isolates of AG2-2 caused severe root rot on mature sugar beet. On wheat, none of the isolates reduced emergence, but isolates of AG4 and AG5 caused significant postemergence root rot. Although some isolates of AG2-2, AG4, and AG5 reduced emergence and caused root discoloration on seedlings of corn, cotton, and sorghum, none was highly virulent on these crops. Both isolates of binucleate *Rhizoctonia sp.* were either avirulent or caused only slight root discoloration. Since AG4, the predominant AG of *R. solani* on wheat, was highly virulent to sugar beet seedlings, wheat preceding sugar beets in rotation is not advised.

RUSH, C. M., R. C. FRENCH, and G. B. HEIDEL. 1993. Texas 7 a possible strain of beet necrotic yellow vein virus. Pages 59-62 *In:* Proc. 2nd Symp. Intl. Wrkg. Grp. Plant Virus Fungal Vectors, Montreal, Canada, July 25-27, 1993.

Restriction enzyme analysis, sequencing of PCR products, and Northern hybridization studies were used to evaluate the relationship between beet necrotic yellow vein virus (BNYVV) and an unnamed furovirus from sugar beet designated Texas 7 (Tx7). Using published sequence data from a European isolate of BNYVV, two pairs of primers specific for each RNA species were synthesized. All primer pairs produced PCR products of the expected size with BNYVV samples. With Tx7 samples, a primer pair specific for the 3' end of BNYVV RNA1 also produced a PCR product slightly smaller than that expected for a BNYVV sample. Restriction analysis indicated the Tx7 PCR product was similar to the BNYVV product but contained a deletion of approximately 30 bases near the 3' end. Sequence analysis indicated the Tx7 PCR product had approximately 75% nucleotide and 96% amino acid homology

with the BNYVV PCR product. Northern blots, using labeled BNYVV PCR products specific for each RNA as probes, also indicated similarities between Tx7 and BNYVV. Probes from the 3' end of BNYVV RNA1, 2 and 4 all hybridized with individual Tx7 RNAs but not probes for BNYVV 5' ends or probes for RNA3. However, when labeled BNYVV cDNA was used as a probe, it hybridized with Tx7 RNA3. Likewise, labeled Tx7 cDNA hybridized with BNYVV RNAs. From these results, we conclude Tx7 is very closely related to BNYVV and is possibly a mild strain with a major deletion in RNA3.

RUSH, C. M., G. B. HEIDEL, R. C. FRENCH, and M. D. LAZAR. 1993. Relationship between BNYVV and an unnamed soilborne sugar beet virus from Texas. 27th Bien. Mtg. of ASSBT, Anaheim, CA, March 3-6, 1993.

A study was conducted using PCR technology to determine similarities between BNYVV and an uncharacterized furovirus of sugar beet designated TX7. Published sequence data of an European BNYVV isolate were used to design synthetic primers for each of the four BNYVV genomic RNAs. Specific primers and reverse transcriptase were used to synthesize cDNA from extracts from BNYVV- or TX7-infected *Chenopodium quinoa* which was then amplified by PCR. Most primer sets generated specific PCR products from BNYVV-infected samples but not from healthy plants or those infected with TX7. However, one set of primers specific for BNYVV RNA1 amplified cDNA from both BNYVV and TX7. The PCR products were ca. 950 base pairs (bp) for TX7 vs. 1056 bp for BNYVV. The apparent deletion in TX7 is located near the 3' end (near base 6200 of BNYVV RNA1). Restriction analysis of the TX7 product using Dra I, Tha I, Nhe I, and Spe I gave RFLP patterns similar to those predicted for BNYVV. In fact, Tha I and Nhe I digestion patterns of TX7 PCR products were more consistent with the published BNYVV sequence than those of our BNYVV isolate. This suggests a high degree of sequence homology between these two viruses in the region of RNA1 defined by these PCR primers. The results of this and other work in our laboratory, including RNA and coat protein analysis, indicate that TX7 and BNYVV are closely related. We speculate that TX7 may be a mild strain of BNYVV.

VAUGHN, K. M. and C. M. RUSH. Integration of biocontrol agents with solid matrix priming of sugar beet seed to reduce seedling damping-off. 27th Biennial Meeting of ASSBT, Anaheim, CA, March 3-6, 1993.

Seed treatment is an attractive delivery system for biocontrol agents. Biocontrol agents *Pseudomonas cepacia*, strain AMMD, and *Gliocladium virens*, strain Cr-4, were used to inoculate sugar beet seed before, during, and after solid matrix priming. Nonprimed seed was also inoculated with both biocontrol agents, and nonprimed and SMP seeds, not inoculated, were used as controls. These ten seed treatments were planted in soils infested with *Pythium aphanidermatum*, *Rhizoctonia solani*, or noninfested soil. The experiment was conducted in growth chambers. Nonprimed

seed treated with Cr-4 caused some phytotoxicity in noninfested soil, but the problem was overcome when Cr-4 was combined with SMP. In *Pythium* infested soil, the addition of AMMD and Cr-4 with SMP reduced postemergence damping-off significantly better than SMP alone and all nonprimed seed treatments, with the exception of nonprimed seed treated with Cr-4. An interaction occurred between AMMD and time of adding the microorganism with SMP. Final stand was significantly increased when AMMD was added during SMP, but not when AMMD was added before of after SMP. In *Rhizoctonia* infested soil, the addition of AMMD and Cr-4 with SMP significantly reduced preemergence damping-off.

VAUGHN, K. M. and C. M. RUSH. **1993. Preliminary studies on the presence of three sugar beet seedling pathogens from major production areas in the USA.** 27th Biennial Meeting of ASSBT, Anaheim, CA, March 3-6, 1993.

Three major soil-borne pathogens which cause sugar beet seedling diseases are *Aphanomyces*, *Rhizoctonia*, and *Pythium*. Presently in the United States, there are no label fungicides for *Aphanomyces*, but fungicides for control of *Rhizoctonia* and *Pythium* are available. Tachigaren is a systemic fungicide that is effective against *Aphanomyces* spp., *Pythium* spp., and some strains of *Rhizoctonia* spp. This fungicide is developed by Sankyo of Tokyo, Japan, and is labeled for use in most countries in Europe, but not in the USA. We are interested in getting EPA clearance for Tachigaren in the USA. As part of this effort, we are trying to determine the geographical distribution of *Aphanomyces* and other major sugar beet seedling pathogens throughout the major growing areas in the USA. This information will be used in trying to secure a label for Tachigaren. So far, soil samples from Idaho (Nyssa and Nampa factory districts), the Red River Valley (Moorehead & Minn-Dak factory district), and Colorado (Ft. Morgan & Greeley factory district) have been screened. *Rhizoctonia* was predominantly isolated from Idaho and Colorado. Low levels of *Aphanomyces* were also found in Colorado. Soil samples from the Red River Valley showed high levels of *Aphanomyces*, with some *Rhizoctonia* isolated.

Papers Published Since Abstracted in Previous Report

HARVESON, R. M. and C. M. RUSH. 1993. An environmentally controlled experiment to monitor the effect of aphanomyces root rot and rhizomania on sugar beet. Phytopathology 83:1220-1223.

HARVESON, R. M. and C. M. RUSH. 1993. A simple method for field and greenhouse inoculation of *Polymyxa betae* and beet necrotic yellow vein virus. Phytopathology 83:1216-1219.

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ETIOLOGY AND EPIDEMIOLOGY OF THE RHIZOMANIA DISEASE COMPLEX
BSDF Project 503

TEXAS 7 A POSSIBLE STRAIN OF BEET NECROTIC YELLOW VEIN VIRUS

C. M. Rush, R. C. French, and G. B. Heidel

In 1988, a virus similar in particle morphology to BNYVV was isolated from Texas sugar beets and designated Tx7 (Liu and Duffus, 1988). Subsequent investigation revealed Tx7 has four distinct polyadenylated RNA molecules of approximately 6.5, 4.2, 1.2 and 1.0 kb (Heidel et al., 1993). Tx7 has a host range similar to that of BNYVV, is vectored by *Polymyxa betae* and frequently is found in the same fields as BNYVV (Heidel and Rush, 1993). Although Tx7 has much in common with BNYVV, it produces symptoms different from those caused by BNYVV on several hosts. Foliar symptoms of Tx7 on sugar beet include a pale yellow discoloration which primarily follows the major leaf veins, mottling, and a slight puckering or distortion. Foliar symptoms can fade or completely disappear from field beets transplanted into the greenhouse, only to reappear later. In such plants, Tx7 can often be detected by ELISA in nonsymptomatic foliage. Tx7 has no obvious adverse effects on root development. On *Chenopodium quinoa*, Tx7 causes diffuse, pale yellow local lesions which may eventually spread along leaf veins. On *Beta macrocarpa* and *B. maritima*, Tx7 causes necrotic local lesions which ultimately develop into systemic infections on *B. maritima* but not *B. macrocarpa*. Because the symptoms produced by Tx7 are similar to those described for RNA3 deletion mutants of BNYVV (Bouzoubaa et al., 1988), studies were conducted to further evaluate differences and similarities between Tx7 and BNYVV. Studies were also initiated to evaluate how certain host plants reacted to dual inoculations with these two viruses.

Materials and Methods

Virus maintenance and purification: Tx7 and BNYVV isolates were maintained in the greenhouse on *C. quinoa* by mechanical inoculation. Procedures for viral purification were similar to those described for purifying sorghum chlorotic spot virus (Kendall et al., 1988). Tx7 isolates used in PCR and hybridization studies were passed through *C. quinoa* four times, while isolates of BNYVV were mechanically transmitted 5-9 times before use.

PCR studies: Two primer pairs were made for each specific BNYVV RNA using published sequence data from European isolates (Bouzoubaa et al., 1985; Bouzoubaa et al., 1986; Bouzoubaa et al., 1987). For each RNA, one primer pair matched the 3' end and one the 5' end. Purified BNYVV and Tx7 RNA were used as templates for first strand cDNA synthesis in reverse transcriptase reactions. cDNA amplification was carried out in a 50 μl reaction using 5 μl cDNA, 10 pmol of each primer, 0.2 mM of each dNTP and 5 U *Taq* DNA polymerase in reaction buffer provided with the enzyme (Robertson et al., 1991).

PCR products were visualized after electrophoresis in a 1% agarose gel by staining with ethidium bromide. Products were cut with various restriction enzymes, and observed fragment sizes were compared with predicted values. One product from RNA1, near the 3' end, was sequenced after gel purification and cloning into pGEM3z (Promega).

Northern blots: After PCR product identity was verified, radioactive probes were made. PCR products were gel purified and used as templates in second round PCR reactions which included ^{32}P labeled dCTP. Radioactive cDNA probes were also produced from unfractionated BNYVV and Tx7 RNA. Northern blots were hybridized with probes as previously described (Church and Gilbert, 1984).

Dual inoculation studies: Local lesions of Tx7 and BNYVV on *C. quinoa* were macerated in 0.1 M KPB pH 7.5 plus 0.02 M Na_2SO_3 and used to inoculate *C. quinoa*, *B. macrocarpa*, and *B. maritima*. Plants were inoculated with each virus independently or with mixed inoculum. Symptom expression was recorded after approximately two weeks, and ELISA tests were conducted to verify the presence of pathogens.

Results

PCR studies: All primer pairs produced expected products in PCR reactions using BNYVV cDNA except the pair specific for the 5' end of RNA3. When Tx7 cDNA was used, only the primer pair specific for the 3' end of RNA1 gave a product close to that expected for BNYVV. Restriction analysis of the Tx7 product, which was slightly smaller than that expected for BNYVV (approximately 1000 vs. 1056 kb, respectively), indicated a high degree of sequence homology. Failure of ThaI to cut the BNYVV product indicated the Texas isolate of BNYVV differed slightly from the European isolate from which the sequence data was derived. ThaI did cut Tx7 and gave products of the size expected for BNYVV as did SpeI, NheI, and DraI.

Sequence analysis of the Tx7 product indicated 75% nucleotide and 96% amino acid sequence homology with the BNYVV product. The deletion in the Tx7 product first observed after electrophoresis of PCR products was determined to be 30 bases in the noncoding region of the 3' terminus.

Hybridization studies: Radioactive probes specific for sequences near the 3' end of BNYVV RNA1, 2 and 4 hybridized strongly with BNYVV RNA and, to a lesser degree, with Tx7 RNA. Neither the specific probe for BNYVV RNA3 nor any probes specific for sequence near the 5' termini hybridized with Tx7, although all hybridized strongly with BNYVV RNA. However, cDNA probes made with an oligo dT primer and nonfractionated BNYVV and Tx7 RNA hybridized with homologous and heterologous RNA, indicating some sequence homology between the four Tx7 and BNYVV RNAs.

Dual infection studies: All hosts inoculated with BNYVV developed bright yellow local lesions which eventually went systemic in *B. macrocarpa* and *B. maritima*. *Chenopodium quinoa* inoculated with Tx7 developed diffuse, pale yellow local lesions. *Beta macrocarpa*

and *B. maritima* inoculated with Tx7 developed necrotic spots surrounded by purple halos. The virus eventually went systemic in *B. maritima* but not *B. macrocarpa*. *Chenopodium quinoa* inoculated simultaneously with BNYVV and Tx7 developed a mottled appearance very different from symptoms on plants inoculated with BNYVV or Tx7 alone. When *B. macrocarpa* and *B. maritima* were inoculated with both viruses, the Tx7 symptom phenotype was dominant. Mixed infections did not change systemic reactions of either virus.

Discussion

Numerous similarities between BNYVV and Tx7 indicate that Tx7 is very closely related to, if not a strain of, BNYVV. They have similar host ranges, exhibit some serological cross reactivity and have coat proteins of similar size. Both are vectored by *P. betae*, and both possess 3' polyadenylated quadripartite genomes (Heidel et al., 1993). To our knowledge, Tx7 is the only recognized furovirus, other than BNYVV, with a quadripartite genome.

Tx7 and BNYVV also have nucleotide sequence homology as shown by PCR and hybridization experiments in this study. Homology exists between all four RNAs, and the degree of homology is greatest near the 3' termini. The greatest molecular variation between Tx7 and BNYVV appears to occur in RNA3. RNA3 of Tx7 is approximately 1.2 kb compared with 1.7 kb with BNYVV. BNYVV PCR probes hybridized with Tx7 RNA1, 2, and 4, but not with Tx7 RNA3. Since BNYVV RNA3 is primarily responsible for symptom phenotype, it is interesting that Tx7, which differs from BNYVV in symptom expression, also differs from BNYVV on a molecular level at RNA3.

There have been numerous reports that wild type isolates of BNYVV possess four full-length RNA species, and that isolates propagated on leaves often possess deleted forms of RNA3 and 4 (Hamilton et al., 1981; Tamada et al., 1990). BNYVV isolates, with deleted forms of RNA3, produce symptoms similar to those produced by Tx7, including diffuse chlorotic spots, necrotic lesions, and an absence of root symptoms (Hamilton et al., 1981; Tamada et al., 1990). Additionally, when "wild type" isolates and RNA3 deletion mutants of BNYVV are inoculated together to *C. quinoa*, the mutant symptom phenotype is dominant (Jupin et al., 1992). In our study, Tx7 symptoms were dominant when Tx7 and BNYVV were both inoculated to *B. maritima* and *B. macrocarpa*.

There is no question Tx7 is very closely related to BNYVV and exhibits numerous characteristics of BNYVV RNA3 deletion mutants. Furthermore, if one uses the criteria suggested by Hamilton et al. (1981) to differentiate viral strains from new viruses, Tx7 should be classified as a strain of BNYVV. If Tx7 is a strain of BNYVV, it is, to our knowledge, the first reported "wild type" isolate with a deleted form of RNA3. However, because of the potential confusion a "mild strain" of BNYVV might create among regulatory agencies, we are withholding our opinion concerning strain designation until further data is gathered.

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Developing Laboratory Techniques for Rearing the Sugarbeet Root Aphid *Pemphigus beta* Doane

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by

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The sugarbeet root aphid, *Pemphigus betae* Doane, is a heteroecious aphid exhibiting two life cycles involving cottonwood trees, *Populus* sp., as its primary host and herbaceous plants such as sugarbeets, *Beta vulgaris* L., as its secondary host. Most damage is done to the sugarbeet when its water and nutrient uptake are interfered with as a result of the aphids feeding on the secondary roots. Both yield and sugar content can be reduced.

Following from our previous research in 1991 and 1992, where a method was developed to rear sugarbeet root aphids in the laboratory, we determined the impact of temperature on the mass increase of sugarbeet root aphids.

The primary objective in this research was to determine at what temperature sugarbeet root aphids exhibited the maximum density increase over a fixed period of time. The results of the experiments were expected to provide optimal growth parameters to scientists who may wish to rear this aphid and also give insights into the temperature regimes in nature where the aphid may rapidly increase in the field.

MATERIALS AND METHODS

A moist, sterile soil mixture contained in petri dishes was used to maintain young sugarbeets about 2 to 4 months old. Four hundred grams of sieved field soil was mixed with 70 ml sterile deionized water, covered, and autoclaved 15 minutes. Beet leaves were removed at the crown and the entire sugarbeet root was used. Beet roots were not subjected to any treatments other than washing 15 minutes with tap water. Working under a laminar flow hood, the sugarbeets were patted dry using sterile paper towels and individually placed in sterile petri dishes containing soil. The plates were wrapped with Parafilm.

Aphids were retrieved from an infested sugarbeet field and transferred directly from infested beets to sugarbeet plates. There were 10 replications of each temperature regime. One newly-born nymph was placed on each sugarbeet, the plates were sealed with Parafilm, and stored in dark incubators set at 5, 10, 15, 20, 25 or 30°C (41, 50, 59, 68, 77, 86°F), depending on the experiment being carried out. The plates remained in the incubators for two weeks. After this time, the plates were opened and all aphids were counted by gently searching through the soil and on the beets themselves. The aphids were separated into nymphs, adults, and alates (winged forms).

Statistical differences between temperature regimes were discerned through Student's *t*-tests for unpaired observations.

RESULTS

The results of the experiment are found in Table 1 and Fig. 1. Generally, the number of aphids increased as temperature increased, but fell sharply at 30°C.

The results indicate that the picture revealed by this experiment is a distribution of aphid densities for the generation following the founder nymph, with some new nymphs representing a second generation produced by first generation adults.

In regard to separate life stages, there were few to no alate aphids produced, except at 25°C, where one was recovered. This result is to be expected since the time-span of the study was short and the environmental conditions for the development of a dispersal phase were probably not present.

Adults were also usually found in low numbers; however, this again may be due to the time span of the experiment. The adult numbers increased with increasing temperature. In the cooler experiments, the few adults may be attributable to a slowing of the developmental period by the cool temperature. The adults that were found are assumed to represent a new generation of aphids, not the original founder nymph. Therefore, these would have been some of the first individuals from the founder nymph. Significantly more adults were found as the temperature increased from 5 to 10°C and from 15 to 20°C. All other pairs of ascending temperatures were not significantly different. Although there were no significant differences among the 20-25-30°C regimes, there was a dramatic drop off (approx. 5-fold) in adult numbers from 25 to 30°C, indicating that at this high temperature regime, some deleterious effects may begin to manifest themselves.

In all temperature regimes, the nymphs were found in the largest numbers. The patterns of significant differences paralleled the adult densities, with the 20 and 25°C being very similar (less than an average of two nymphs difference), and a substantially less rapid fall between 25 and 30°C. However, as with the adult densities, this fall may indicate a point where the temperature begins to cause aphid mortality.

Table 1. Sugarbeet root aphid density increase research

Temp.	Avg. aphids		Student's *t*-test, unpaired observations		
°C	per plate	Std Dev.	*t*	df	Table *t* at P=0.05
		Adults			
5	0.0	0.0	7.61	17	2.11 *
10	2.2	0.8	0.84	17	2.11 ns
15	2.0	2.5	2.90	18	2.10 *
20	5.2	3.9	0.32	18	2.10 ns
25	11.3	11.7	1.37	16	2.12 ns
30	2.9	1.0			
		Nymphs			
5	0.1	0.3			
10	4.0	1.3	7.19	17	2.11 *
15	1.2	2.5	1.97	17	2.11 ns
20	21.1	17.4	3.65	18	2.10 *
25	22.5	9.3	0.12	18	2.10 ns
30	13.8	5.2	0.31	16	2.12 ns
		Alates			
5	0.0	0.0			
10	0.0	0.0	na		
15	0.0	0.0	na		
20	0.0	0.0	na		
25	0.1	0.3	na		
30	0.0	0.0	na		

Beet variety was HH39

DISCUSSION

The experiments conducted to this date in regard to sugarbeet root aphid development in the laboratory have yielded both a workable technique for rearing this pest in a laboratory situation, and also give an indication of the developmental parameters. From our results, we conclude that if our technique is used, laboratory colonies of sugarbeet root aphids can be stored in a temperature range from 10 to 25°C. As the temperature increases, the production of nymphs and adults also increases. Alate forms are not a problem during short time spans, however, after longer storage times, they may develop more rapidly. Additional research should be carried out to determine the effects of temperatures on both the maximum time a colony can survive at higher temperatures, and how long the beet can remain a suitable host. Although our results indicated that the aphids do not do well at 5°C, it would be interesting to see if a colony can be maintained at low densities at these temperatures.

This could be very important to a researcher who would like to maintain a colony in between experiments, when sugarbeet root aphids from the field or fresh sugarbeets are not available.

The results of our experiments may indicate, additionally, where sugarbeet root aphids may be found in the field. As soil temperatures warm in the spring, aphids which have overwintered in the soil may move up in the profile to take advantage of the more favorable temperatures. Conversely, as summer temperatures rise above 30°C (96°F), aphids may again move down in the soil profile. If this movement does occur, it would be very important for non-systemic insecticides to be applied in such a manner that they penetrate far enough into the soil profile to reach levels where the soil temperature is conducive to rapid aphid growth. If insecticides (especially granules) were applied to the surface and not watered into the profile, there is a good chance that they may never reach the depth where most of the aphids congregate.

The results of this laboratory research open a number of other avenues that need to be explored. Longer time periods at constant temperatures would yield definite upper and lower temperature limits. Field studies that correlate aphid location in the soil with soil temperature may be very useful in applying these laboratory results to a practical situation involving chemical control of the sugarbeet root aphid.

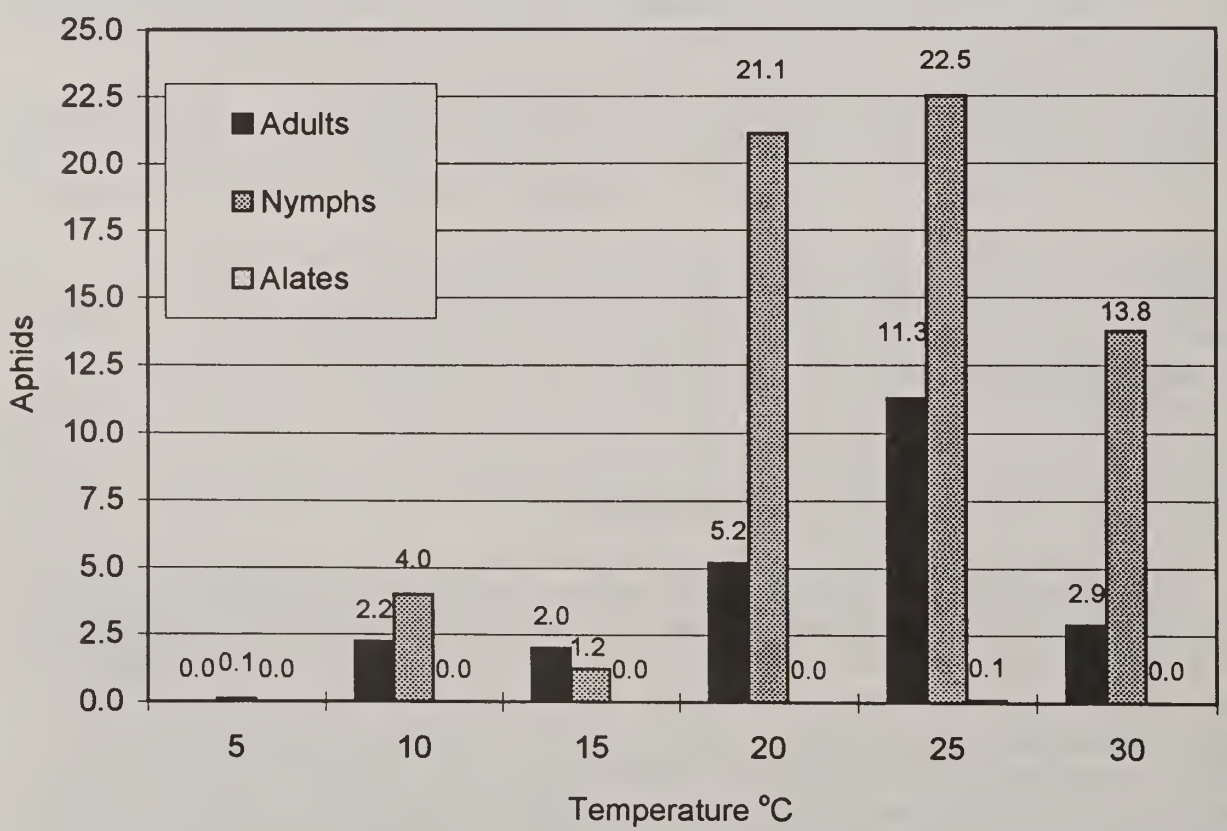

Fig. 1. Effects of temperature on sugarbeet root aphid increase.

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